december, 1960

nlgi spokesman

journal of the national lubricating grease institute

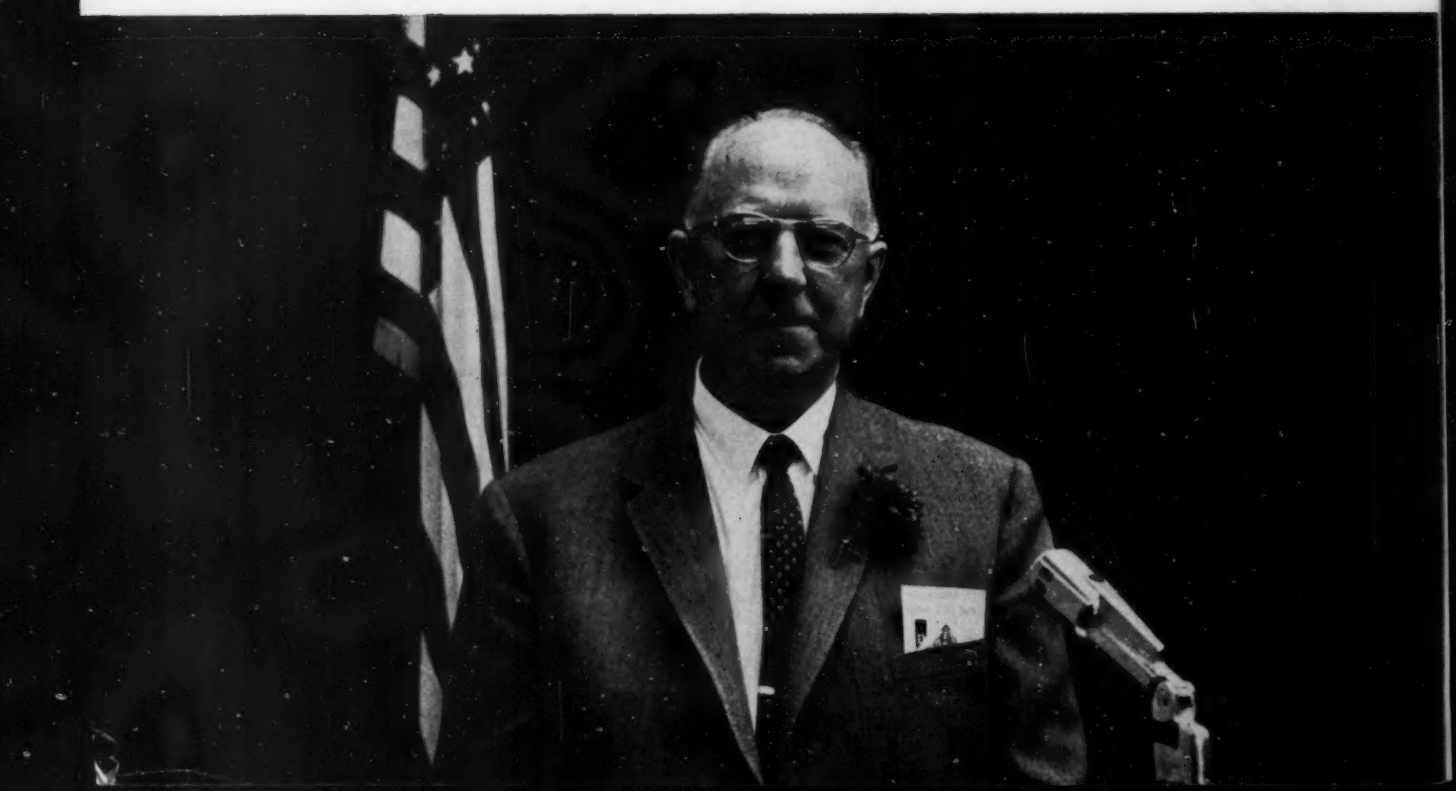
NLGI Elects F. R. Hart as Its 28th President

President's Address—1960

Newly-Elected Officers and Directors for 1960-61

An Interpretation of NLGI's 1959 Production Survey
By T. F. SHAFFER

Structural Changes and Phase Transitions in Lithium Greases
By R. M. SUGGITT



Better Greases Through BAROID RESEARCH

BARAGEL 24* provides greater stability in greases made from non-petroleum oils

BARAGEL 24, a non-soap grease-gelling agent, gives greater stability to greases made from such non-petroleum oils as polyalkylene glycols, di-2-ethylhexyl sebacate, di-2-ethylhexyl adipate and castor oil. The development of BARAGEL 24 is another result of Baroid Chemicals' research.

Greases compounded with BARAGEL 24 are subjected to the most rigid testing. One of these tests measures grease penetration over the range of unworked to 10,000 strokes. In non-petroleum based oils, BARAGEL 24 produces greases that are exceptionally stable to working in the ASTM grease worker. These greases show minimum breakdown under the most rigorous operating conditions.

BARAGEL 24 is a reaction product of organic ammonium halides and refined sodium montmorillonite. BARAGEL 24 is a member of the BARAGEL-BENTONE* family of products which has been used so successfully in greases, plastics, paints, inks and other fields.

*Trademark of National Lead Company for an organic ammonium montmorillonite

5074

BAROID

BAROID CHEMICALS, INC.

A SUBSIDIARY OF
NATIONAL LEAD COMPANY

1809 SOUTH COAST BUILDING
HOUSTON 2, TEXAS

nlgi spokesman

Volume XXIV December, 1960 Number 9

Published Monthly by the National Lubricating Grease Institute, T. W. H. MILLER, Editor; VIRGINIA ALLEN, Assistant Editor, 4638 J. C. Nichols Parkway, Kansas City 12, Missouri. Telephone VAlentine 1-6771. 1 Year Subscription, $3.00. 2 Year Subscription (Foreign), $6.00.

OFFICERS AND DIRECTORS

President: F. R. HART, Standard Oil Co. of California, 225 Bush Street, San Francisco, Calif.

Vice-President: C. L. JOHNSON, Jesco Lubricants Co., P. O. Box 7331, North Kansas City, Mo.

Secretary: T. F. SHAFFER, Shell Oil Co., 50 West 50th Street, New York 20, N. Y.

Treasurer: A. J. DANIEL, Battenfeld Grease and Oil Corp., Inc., 3148 Roanoke Road, Kansas City 11, Mo.

W. W. ALBRIGHT, Standard Oil Co. (Indiana), 910 S. Michigan, Chicago, Ill.

S. C. M. AMBLER, British American Oil Co., Bay & College St., Toronto, Ontario, Can.

T. W. BINFORD, D-A Lubricant Co., Inc., 29th St. and Canal, Indianapolis 23, Ind.

E. W. CAMPBELL, Gulf Oil Corp., P. O. Box 2140, Houston, Texas

J. J. COATES, Esso Standard Div., Humble Oil & Refining Co., 34th and Smallman St., Pittsburgh 1, Pa.

R. CUBICCIOTTI, Sonneborn Chemical & Refining Corp., 300 Park Avenue South, New York, N. Y.

H. B. ELLIOTT, Atlantic Refining Co., 260 S. Broad St., Philadelphia 1, Pa.

J. W. LANE, Socony Mobil Oil Co., Inc., 150 E. 42nd St., New York 17, N. Y.

W. A. MAGIE, II, Magie Brothers Oil Co., 9101 Fullerton Avenue, Franklin Park, Ill.

H. A. MAYOR, JR., Southwest Grease & Oil Co., Inc., 220 W. Waterman, Wichita, Kans.

G. E. MERKLE, Fiske Brothers Refining Co., 129 Lockwood Ave., Newark 5, N. J.

F. W. MINOR, Sinclair Refining Co., 600 Fifth Avenue, New York 20, N. Y.

W. M. MURRAY, Kerr-McGee Oil Industries, Inc., Kerr-McGee Bldg., Okla. City, Okla.

G. A. OLSEN, Sunland Refining Corp., P. O. Box 1512, Fresno, Calif.

F. E. ROSENSTIEHL, Texaco, Inc., 135 East 42nd Street, New York 17, N. Y.

W. H. SAUNDERS, JR., International Lubricant Corp., Box 390, New Orleans, La.

N. D. WILLIAMS, The Pure Oil Co., 200 E. Golf Road, Palatine, Ill.

Technical Committee Chairman: L. C. BRUNSTRUM, Standard Oil Co. (Indiana) Whiting Research Laboratory, Box 431, Whiting, Ind.

General Manager: T. W. H. MILLER, NLGI, 4638 J. C. Nichols Parkway, Kansas City 12, Mo., VAlentine 1-6771

IN THIS ISSUE

President's Page 346

Future Meetings 349

News About NLGI 351

NLGI Elects F. R. Hart as Its 28th President 355

President's Address—1960 356

Newly-Elected Officers and Directors for 1960-61 361

An Interpretation of NLGI's 1959 Production Survey 363
T. F. Shaffer, Shell Oil Company

Structural Changes and Phase Transitions in Lithium Greases 367
R. M. Suggitt, Texaco Inc.

Literature and Patent Abstracts 376

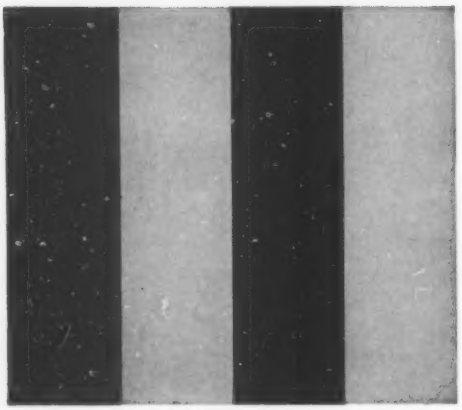
Industry News 382

People in the Industry 384

THE COVER

PRESIDENTS of NLGI are chosen by the Board of Directors, only after the candidate has served on the governing body in a number of capacities, working on committees and acting as chairman of one or more. Traditionally, the man who plans and puts together the all-important annual meeting in the capacity of vice-president and program chairman then moves to the position of the Institute's chief executive . . . after experience in every phase of NLGI's sphere of activities. The new president, the Institute's 28th, is F. R. Hart, shown on our cover after his election at the recent annual meeting.

The NLGI SPOKESMAN is indexed by Industrial Arts Index and Chemical Abstracts. Microfilm copies are available through University Microfilm, Ann Arbor, Mich. The NLGI assumes no responsibility for the statements and opinions advanced by contributors to its publications. Views expressed in the editorials are those of the editors and do not necessarily represent the official position of the NLGI. Copyright 1960. National Lubricating Grease Institute.



NLGI PRESIDENT'S PAGE

By F. R. HART, *President*

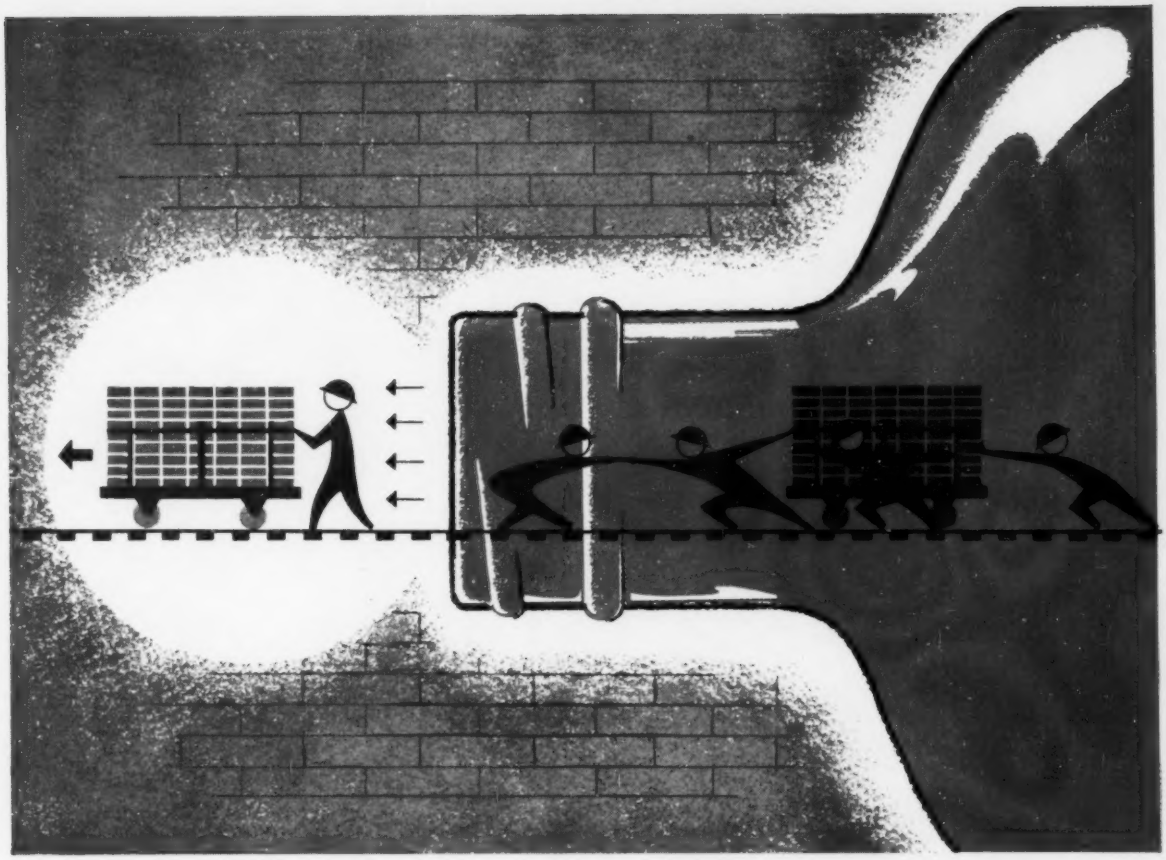
1961 Provides New Opportunities

In just a few short days, a new year will be born and with it a host of new opportunities. The years pass so swiftly that one must take full advantage of each development to successfully compete in a fast-changing market. This is particularly true of the lubricating grease industry because of its dependence on machine design and use. Because we are a secondary industry, the challenge is greater, more personal and certainly more complicated than would be the case in some other less dependent activity.

I firmly believe the future of the lubricating grease industry lies in its willingness to be honestly critical of its business policies, its products and its marketing methods and to make such changes as circumstances warrant. The difficult part is the willingness to adjust—to innovate, to pioneer new fields of development. Our industry could turn out better lubricating greases, products of such improved service properties as to stimulate increased demand. Also, improvements appear timely for better methods of grease application. A good example of package pioneering is the large collapsible, heavy-duty rubber bag used to fill and ship bulk lubricating grease to steel mills. This device may not be the final answer but it is a new idea—a prime example of package and market development.

Never before has the American market provided more opportunities for new product development. The enlarged industrial market, the mechanized farm market, the growing need for military lubricants, the ballistic missile development, the commercial use of atomic energy, the fact that this nation moves on wheels and produces with machinery are the motivating forces to stimulate new thinking. This vast mechanical market is in its infancy and will continue to expand if for no other reason than the need to cut the rising cost of doing business. Opportunities exist to do a better job of marketing. Consideration might be given to package selling (grouping allied products into a single package deal). Certainly much can be done to train sales representatives so that each buyer gets the facts. Much more can be done toward product simplification, thus accelerating product demand. And finally, a big opportunity exists to improve earnings through more realistic product pricing.

Yes, the coming year provides opportunity and a challenge to all who desire to perpetuate and seek a larger share of the lubricating grease market.



New "hot" grease ends brick-oven bottlenecks

. . . and one man outperforms four!

Ceramic Combustion & Engineering Company, consultants for the Davidson Brick Co., Los Angeles, California, ran into production bottlenecks while using ordinary grease in dryer-car bearings. Oven temperatures (350° to 400° F.) cooked the grease solid . . . stalled the cars loaded with bricks in the dryer. Bearings seized so badly that four men were needed to move each carload.

Now—with Shell Darina Grease 2 as the lubricant, Davidson reports: "Bearings roll free, even at 400° F., one man, instead of the four previously required, can *easily* roll a carload of bricks . . . no more bottlenecks caused by frozen bearings."

Darina® Grease 2 is an economical, multi-purpose grease with exceptional stability in high-temperature applications. It offers these outstanding qualities:

HIGH-TEMPERATURE PERFORMANCE. *100° F. better* than conventional multi-purpose greases.

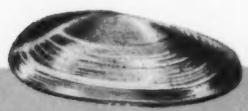
EFFICIENT SEALING. Contains no soap —nothing to melt and run out.

HIGH RESISTANCE TO WATER WASH-OUT. Doesn't dissolve or separate when mixed with water . . . lubricates efficiently under wet conditions.

POSITIVE RUST PROTECTION. Protects bearings even under severe moisture conditions.

ECONOMICAL. Savings up to 35% in grease and labor costs alone are possible because of Darina's superior performance over a wide range of plant operating conditions.

For more information on Darina Grease, write: Shell Oil Company, 50 West 50th St., New York 20, N. Y., or 100 Bush St., San Francisco 6, California. In Canada: Shell Oil Company of Canada, Limited, 505 University Avenue, Toronto 2, Ontario.



An Interesting Fact! Every Shell Branded Industrial Lubricant is named for a sea shell. Shown here: Darina solenoides.

SHELL DARINA GREASE

the multi-purpose, high-temperature grease

SHELL

"There is an honor in business that is the fine gold of it; that reckons with every man justly; that loves light; that regards kindness and fairness more highly than goods or prices or profits."

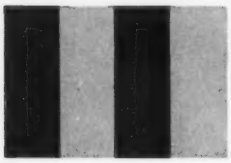
"It becomes a man more than his furnishings or his house; it speaks for him in the heart of everyone. His friendships are serene and lasting."

Henry Wadsworth Longfellow

Merry Christmas
and Best Wishes for a
Prosperous New Year

CATO OIL AND GREASE COMPANY

Oklahoma City, Oklahoma



Future Meetings

JANUARY, 1961

9-13 Society of Automotive Engineers Annual Meeting, Cobo Hall and Convention Arena, Detroit.

FEBRUARY, 1961

5-10 ASTM Committee D-2 meeting, Benjamin Franklin Hotel, Philadelphia, Pa.

15 NLGI Board of Directors meeting, Sheraton-Cadillac Hotel, Detroit.

DENCO

Manufacturers of Lubricants (since 1901)

Manufactured and Packaged to Your Requirements

Call or write

DENCO PETROLEUM COMPANY

5115 DENISON AVE.

CLEVELAND 2, OHIO

OLYMPIC 1-6600

APRIL, 1961

11-13 American Society of Lubrication Engineers Annual Meeting and Exhibit, Bellevue-Stratford Hotel, Philadelphia.

19-20 National Petroleum Association, Semiannual Meeting, Sheraton-Cleveland Hotel, Cleveland.

MAY, 1961

8-9 ASME Lubrication Symposium, Deauville Hotel, Miami Beach, Fla.

13 NLGI Board of Directors meeting, Hollywood Beach Hotel, Hollywood Beach, Fla.

16-19 API Division of Marketing, Midyear Meeting, Americana Hotel, Miami Beach, Fla.

JUNE, 1961

11-15 ASME Summer Annual Meeting, Statler Hilton Hotel, Los Angeles.

24-29 ASTM Committee D-2 meeting, headquarters undecided, Atlantic City, N. J.

SEPTEMBER, 1961

11 NLGI Board of Directors meeting, Roosevelt Hotel, New York City.

13-15 National Petroleum Association, Annual Meeting, Traymore Hotel, Atlantic City.

OCTOBER, 1961

17-19 ASME-ASLE Lubrication Conference, Hotel Morrison, Chicago.

OCT. 29 - NOV. 1, 1961 NLGI Annual Meeting, Rice Hotel, Houston, Tex.

NOVEMBER, 1961

26-Dec. 1 ASME Winter Annual Meeting, Statler Hilton Hotel, New York.

QUALITY LUBRICANTS

INDUSTRIAL

AND

AUTOMOTIVE

Manufactured for

REFINERS

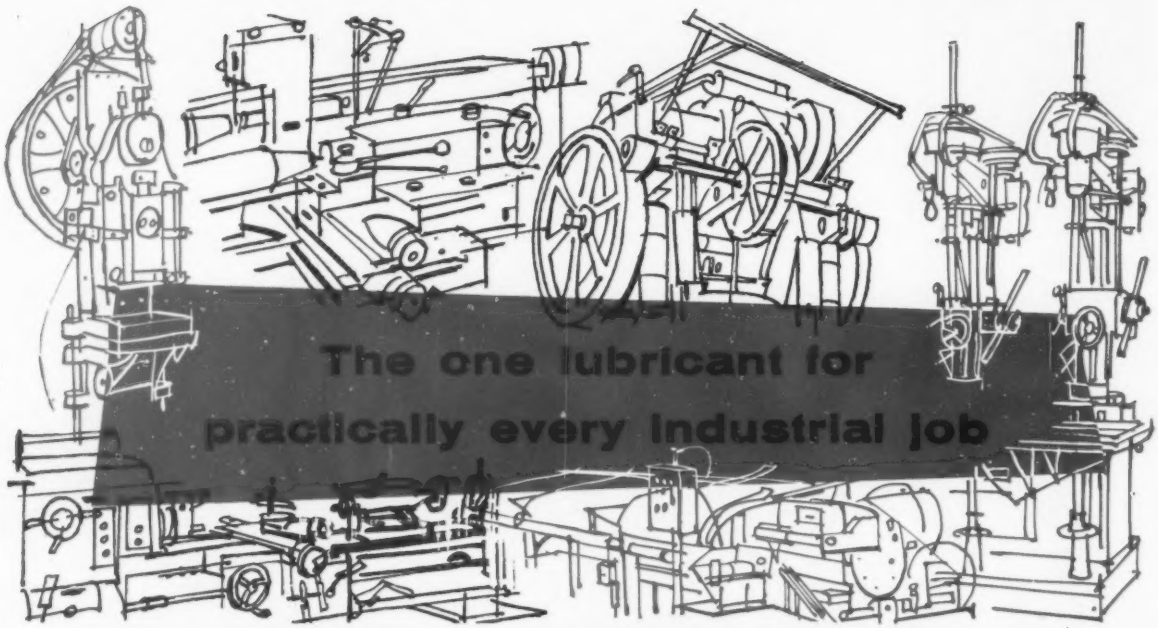
COMPOUNDERS

JOBBERS

FISKE BROTHERS REFINING CO.

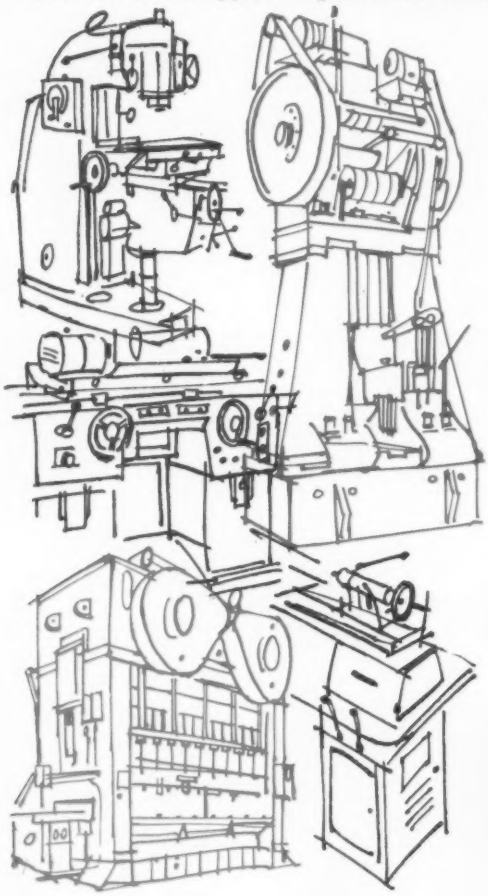
PLANTS

Newark, N. J. Toledo, Ohio



ATLANTIC LUBRICANT 54

Performs on all types of grease-lubricated machinery • Cuts cost • Reduces lubricating errors



Atlantic Lubricant 54—an outstanding multi-purpose lubricant—assures:

- **Wider application**—almost universal application to grease-lubricated equipment in plants of all sizes
- **Excellent performance** at very high to extremely low operating temperatures
- **Reduced losses** from lubricating error
- **Lower costs** of warehousing and handling
- **Outstanding rust protection** for all ferrous surfaces
- **Unusual stability** against oxidation and softening—even under very rugged conditions
- **Easy, positive identification**—thanks to Atlantic Lubricant 54's distinctive purple color

Available from conveniently located warehouses. Call any of the Atlantic offices listed below.

ATLANTIC

LUBRICANTS • WAXES
PROCESS PRODUCTS

PHILADELPHIA, PA.
260 So. Broad St.

PITTSBURGH, PA.
Chamber of Commerce Building

PROVIDENCE, R.I.
430 Hospital Trust Building

SYRACUSE, N.Y.
Salina and Genesee Streets

CHARLOTTE, N.C.
1112 South Boulevard

In South America
Atlantic Refining Company of Brazil, Rio de Janeiro

News About NLGI

New Surpass Joins NLGI

New Surpass Petrochemicals, Ltd., Toronto, Ontario, Canada, has joined NLGI as an Active member. Fred W. Evans will serve as Company representative while William Blokhwis will act as Technical representative to the Institute.

Changes Representative

Ohio Farm Bureau Cooperative association of Columbus has named T. L. Young, manager of the petroleum division, as Company representative to NLGI for this Marketing member firm.

Thanks Sponsors of Early Bird Reception

A resolution of thanks was offered by H. A. Mayor, Jr., immediate past president, prior to his turning the gavel over to F. R. Hart. Mayor acknowledged the contributions of 30 Associate members of the Institute for sponsoring the "Mr. and Mrs. Early Bird Reception" during the first day of last month's annual meeting. (See page 257 of the October NLGI SPOKESMAN for the list of host firms.)

Thanks to the support of these companies, one of the best meetings in the history of the Institute was off on a high note with the Early Bird party. The NLGI SPOKESMAN would also like to add its thanks, for the rest of the Institute.

29th Annual Meeting To Be Held in Houston

By a unanimous decision of the NLGI board of directors, the 29th Annual Meeting of the Institute will be held at the Rice hotel in Houston, Texas. Meeting days will be Sunday through Wednesday, October 29-November 1, 1961.

Sample Production Survey Questionnaire Out Soon

All members of the Institute will receive sample mailings in mid-December concerning the questionnaire of the 1960 Production Survey. This will serve as an advance warning for the actual questionnaires, mailed to Active U. S. and Canadian manufacturers, in mid-January.

Cato Donates Film On Fire to NLGI

NLGI's film library now has a new motion picture on "Lessons to be Learned from the Cato Grease Plant Fire," just presented to the membership at the recent annual meeting.

The 16mm sound film was donated by Ralph Jenks, Howard Wixson, Leon Oswalt and Claude Huffman of Cato Oil and Grease company after the picture was shown in Chicago last month. Running time is 26 minutes, and the movie shows the disastrous fire set by an arsonist last year, along with a step-by-step recovery of the firm's manufacturing, research, office and sales departments after the embers had cooled.

Each department head traces what was done to recover from destroyed or damaged files or fixtures and in his narration, explains what steps other manufacturers might take to eliminate being crippled by fire or any other disaster. The various points are repeated, making this picture excellent for in-plant training of manufacturing personnel.

Bookings of the "Lessons to be Learned" film are being made at the NLGI national office on a first-come, first-served basis. Members are sent the picture without charge and are asked to return it within ten

Continued on page 352

SERVICE AIDS

Send Orders to: National Lubricating Grease Institute, 4638 Nichols Pkwy., Kansas City 12, Mo.

NLGI GLOSSARY—A four-page booklet containing definitions of terms relating to the lubricating grease industry. Usable by marketing as well as technical people. Fifteen cents per copy (NLGI member price) and twenty-five cents (non-member).

REPRINTS — From the NLGI SPOKESMAN are available at low cost. Page forms are left standing for three months, company imprint or advertising arranged.

NLGI MOVIE — "Grease, the Magic Film," a 16-mm sound movie in color running about 25 minutes, now released. First print $300, second and subsequent orders $200 each (non-members add $100 to each price bracket).

LINCOLN MOVIE — "You—the Jury," a 16-mm sound movie in color, 18 minutes, telling the application story in the lube bay. May be reserved without charge from NLGI. A gift of Lincoln Engineering Co.

CATO MOVIE — "Lessons to be Learned from the Cato Grease Plant Fire." A 16-mm sound movie, 26 minutes, depicting how to avoid a fire in a lubricating grease manufacturing plant with step-by-step procedures.

Continued on page 352

News About NLGI cont'd

days. Once member commitments have been filled, non-member firms may request it.

Other prints in the NLGI film library include copies of the Institute's own movie, "Grease—the Magic Film," a 26-minute film on development and application of lubricating greases from ancient times up to the present, with stress on the research necessary to manufacture a product. It is in 16mm sound, with color. NLGI also has a copy of the Lincoln Engineering movie, "You—the Jury," in 16mm color, with sound. This picture is about 18 minutes and is a dramatic presentation telling the application story in the lube bay.

Any of these movies may be borrowed for showings by contacting NLGI.

Technical Committee Column

CHAIRMAN L. C. BRUNSTRUM
Research & Development Dept.
Standard Oil Company (Ind.)
P. O. Box 431
Whiting, Ind.

Mr. Robert S. Barnett, of Texaco Inc., has been appointed a vice-chairman of the technical committee. "Spence" is eminently qualified for this task; his experience includes both lubricating grease and committee work. Also, Mr. M. L. Carter, of Southwest Grease and Oil Co., will serve another year as a vice-chairman. The technical committee's thanks and appreciation are extended to the retiring vice-chairman, Mr. M. J. Pohorilla.

Attendance at the varied research sessions on November 1, 1960, reached a maximum of 80. This was the same attendance as the first research session in 1958, when Henry Eyring, W. H. Bauer, A. W. Sisko and J. L. Dreher spoke on grease rheology. In 1958 there was only one technical session.

Plans for the 1961 technical sessions are already underway. One will be the joint ASTM-NLGI symposium on the significance of oil viscosity in lubricating grease. Another may be either a symposium on lubrication frequency versus performance or a symposium on presentation of technical papers on lubricating grease in the NLGI SPOKESMAN or to NLGI audiences. The chairmen need a great deal of assistance with all three symposia; if you are willing to help in any way, please contact the following:

Oil Viscosity

R. S. Barnett—Texaco Inc., P. O. Box 509; Beacon, New York.

J. J. Dickason—Jesco Lubricants Co., 1437 Gentry St., North Kansas City, Missouri.

Lubrication Frequency

P. V. Toffoli—The Pure Oil Co., 200 East Golf Road, Palatine, Illinois.

M. L. Carter—Southwest Grease & Oil Co., Inc., 220 W. Waterman St., Wichita 2, Kansas.

Paper Presentations

C. J. Boner—Battenfeld Grease & Oil Corp., 3148 Roanoke Road, Kansas City 8, Missouri.

G. Entwistle—Sinclair Refining Co., 410 East Sibley Boulevard, Harvey, Illinois.

A. S. Orr—Gulf Oil Corp., P. O. Box 1166, Pittsburgh, Pennsylvania.

Plan to attend these significant sessions at the 1961 Annual Meeting in Houston.

Continued from page 351

WHEEL BEARING MANUAL — "Recommended Practices for Lubricating Automotive Front Wheel Bearings." More than 170,000 copies of this booklet have been distributed throughout the world. Now in its sixth printing. Sixteen pages, with more than 40 illustrations. Twenty-five cents a copy, with quantity discounts — company imprint arranged.

BONER'S BOOK—Manufacture and Application of Lubricating Greases, by C. J. Boner. This giant, 982-page book with 23 chapters dealing with every phase of lubricating greases is a must for everyone who uses, manufactures or sells grease lubricants. A great deal of practical value. $18.50, prepaid.

BALL JOINT BOOKLET — "Recommended Practices for Lubricating Passenger Car Ball Joint Front Suspensions." The latest aid in application, created by experts in the field and designed for use in the station. Twelve pages, easy to read, with large illustrations throughout. Twenty-five cents a copy with quantity discounts—company imprint arranged.

now available *now available*

NLGI SPOKESMAN

VOLUME XXIII

Latest Issue of Institute's Journal In Bound Volumes Offered to Readers

A reference work which is both handsome and practical . . . Volume XXIII of the NLGI SPOKESMAN contains the twelve issues between April, 1959 and March of 1960 . . . 36 features on every phase of the lubricating and fluid gear lubricants industries. Some categories:

> Automobiles . . . automatic transmission fluids . . . fatty acids . . . manufacture . . . non-soap . . . non-soap thickeners . . . testing . . . gear lubricants . . . marketing . . . non-lubricated bearings . . . and others.

The sturdy green cover holds all twelve issues securely, with an index in the final magazine broken down by author, title and category. A few copies of Volume XXI and XXII are also available. Write NLGI, 4638 J. C. Nichols Parkway, Kansas City 12, Missouri. $7.50 for members, $10.50 for friends of NLGI, plus postage.

Volumes I through XXIII may be purchased from University Microfilms, 313 North First Street, Ann Arbor, Michigan.

More cars than ever have to be greased with "Moly" Grease

Recently major automotive manufacturers dramatically recognized the technical superiority of molybdenum disulfide. They began to turn out 1961 models factory-filled with "Moly" Grease . . . in some cases advertising that models will not need relubrication for 30,000 miles.

The same qualities that the car manufacturers have recognized can be put to use in many industrial applications. Essentially there are five fundamental characteristics of Molysulfide® which account for its unmatched excellence in so many lubricating applications:

- **It has a very low coefficient of friction which decreases as load and sliding speed increases.**
- **It has a natural affinity for metal surfaces.**
- **It resists pressure far beyond the yield point of most metals.**
- **It has high thermal and chemical stability.**
- **It performs over a wide temperature range from −300 F to 750 F (over 2000 F in an inert atmosphere).**

As a result, Molysulfide lubricants resist galling and seizing more than any other known lubricating ingredient.

If you would like to have more complete technical data on Molysulfide and how it might be the answer to your lubricating problems, Address: CLIMAX MOLYBDENUM COMPANY . . .

CLIMAX MOLYBDENUM

CLIMAX MOLYBDENUM COMPANY

a division of American Metal Climax, Inc.

1270 Avenue of the Americas, New York 20, N.Y.

NLGI Elects F. R. Hart As Its 28th President

F. R. Hart was elected 28th president of the National Lubricating Grease Institute during a meeting of the NLGI in Chicago November 1, 1960. He has previously served as vice-president and program chairman.

Hart was elected to the NLGI's board of directors in 1955. He has served on eleven committees for the Institute, including chairmanship of the committee for the organization's journal, the NLGI SPOKESMAN, and the 1960 convention planning committee.

He has been associated with the oil industry for more than 42 years. Hart is a supervisor for marine and industrial lubricant sales, lubricant division, wholesale sales department, Standard Oil Company of California—Western Operations, Inc.

His home is in Orinda, California.

PRESIDENT'S ADDRESS—1960

Remarks by the 27th President of the National Lubricating Grease Institute at the Annual Meeting, Chicago, Ill.

By H. A. MAYOR, JR.
Immediate Past President, NLGI

YOU'LL never realize how proud it makes me to extend, on behalf of the NLGI officers and board of directors and our hard-working staff, a warm, sincere welcome to each of you at this opening session of the 28th Annual NLGI gathering. And believe me, it's a real thrill for this grease peddler from the plains of Kansas to share this rostrum this morning with devoted, experienced, qualified industry men like Frank Hart, Charlie Guzzo and Claude Johnson. Leading off for a line-up of that caliber, you can't help but be somewhat nervous and anxious, so forgive me if any such outward signs exist. If only there were a photographer on hand who could somehow arrange a picture with these industry stalwarts in the background. He'd have one good customer for I'd like to present each member of our company's board of directors a copy in support of my plea for higher salary and more liberal expenses next year.

It makes me proud, too, to realize that each of you have taken the time from busy, complicated, difficult job schedules, in many instances at much expense, to rally around the NLGI flag. Somehow, just the sight of this many people, who are in someway interested enough in the grease industry to be here today, makes me know that the big, serious problems of our industry are not insurmountable. If, through the medium of this meeting, we can somehow find a way to mold together the abilities and the strength and the desire that exist individually in this room today, our industry ills could be remedied. And, as all of us realize, those ambitious guys in Detroit with their dreams of a service-free car, teamed-up with their enthusiastic advertising copywriters, do create problems for all of us. If you don't think so, just be sure to be on deck for Hunt Eldridge's paper covering the "Lubricating Grease Re-

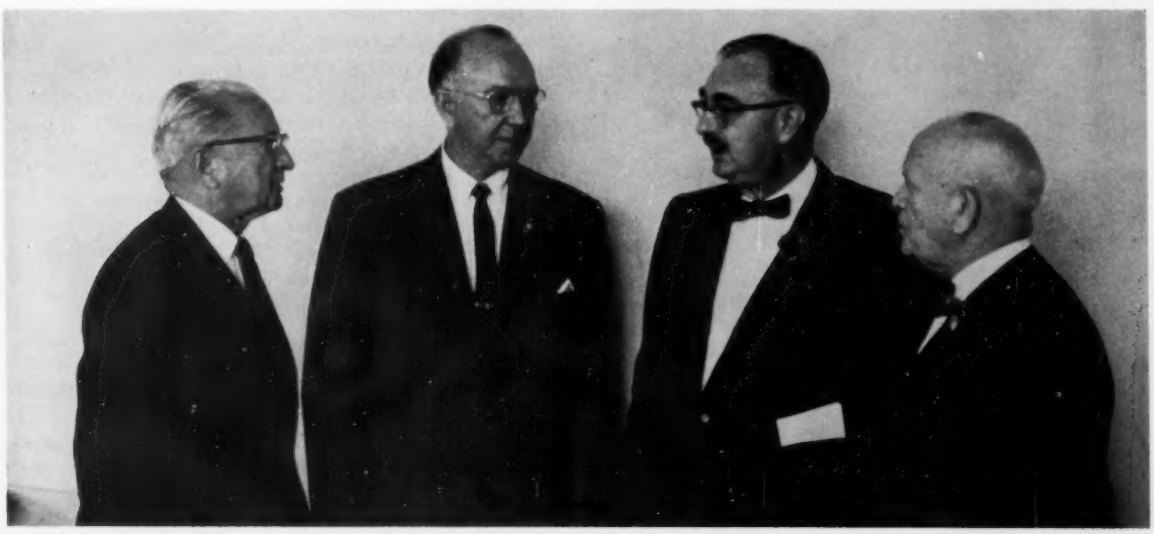
ALTHOUGH one of the youngest men ever to hold the office of president of the National Lubricating Grease Institute, H. A. Mayor, Jr., is a veteran in the lubricating grease industry, having worked up from the plant to his present position of executive vice-president of Southwest Grease and Oil Company, Inc. Elected to the NLGI board of directors in 1953, he has chairmaned a number of committees and served as vice-president and head of the Annual Meeting during the 1958-59 administration. He was elected 27th president last year and completed his term of office at the Annual Meeting in Chicago this October. He has contributed to the SPOKESMAN *before.*

quirements of 1961 Cars" scheduled to kick-off tomorrow's afternoon marketing session in this room. There are strong indications that serious marketing problems related to the 1961 lubricant program for certain famous automobile manufacturers have already developed. It looks as though we grease monkeys may get a turn at bat sooner than we expected. Although we may give our banker friends ulcers while we're doing it, we can at least bask comfortably in the knowledge that in the short seven years since Harry Wolf of General Motors stood before us and argued convincingly that our chassis lubricants deteriorated beyond "the satisfactory use" point after 200 miles of service, we now can produce 30,000 mile chassis greases that perform satisfactorily.

Historically, this is an opportunity to take a short backward glance (a more constructive one than mentioned above) at the NLGI year just ended. Using the common language of the day, such a glance leaves me with mixed emotions. Naturally, it will be a relief to have more time available for purely selfish, corporate and personal projects. All of my associates will now soon know if my alibis for the last two years about unfinished business were valid. It's hoped my competitors will realize that there's been a change in my personal time allocation also. On the other hand, the need for industry-wide action and coordination during this year has been so great, it is disappointing to realize that more constructive NLGI work has not been accomplished during 1960. And in the same vein, it's been disappointing and frustrating to find out how far out of balance my personal, industry indebtedness is with my ability to pay. Contrary to my hopes at the beginning of the year, it will take more than just a few years to balance the books.

There is that comforting old adage, however, that good things take time and perhaps the pot that has been kept boiling all year, although the stew isn't cooked now, will serve up a square meal sometime in the future. Let's take a few moments to review the projects we have had on the stove this year.

Concurring with the expressed desire of all of my most recent predecessors, and in direct response to John McCollister's plea from this same rostrum last year, it was hoped by many of us that 1960 would see the establishment of a full-fledged NLGI Marketing Committee—patterned similarly to our imminently successful and effective Technical Committee. A new Board Marketing Committee was appointed this year to explore and develop such possibilities. Under the organization envisioned, each Active member would be entitled to an appointment to the parent committee. Sub-committees would then be formed to deal and cope with specific areas of interest within the total marketing picture (about which you will hear more in Claude Johnson's good paper later in this same session). Much thought and study was expended in this direction. The project was temporarily sidetracked when the entire board took a very long and close look at a very comprehensive proposal from Battelle Memorial Institute, one of our technical members, entitled "An Economic Study of Lubricating Grease Markets and Technical Planning for Future Industry Growth." This was an all encompassing proposal that could have well been a solid foundation for an NLGI Marketing Committee structure. However, the board rightfully decided that the Battelle proposal covered a program the NLGI could not afford—at least not until



1961 officers include: Treasurer A. J. Daniel (Battenfeld, K. C.) serving his ninth consecutive year, President F. R. Hart (Standard of California), Secretary T. F. Shaffer (Shell), and Vice-President C. L. Johnson (Jesco). Daniel and Shaffer were also re-elected to the Board for three-year terms.

every avenue of possible intra-industry work in the same general field was explored. The interest developed from this year's discussions about the possible Marketing Committee structure is still smoldering and perhaps those that follow can fan the embers into a blaze. Here's one guy that hopes so.

Under the very capable and effective leadership of Larry Brunstrum who, thank goodness, stepped into the big, well broken-in shoes of Ted Roehner without losing a step, the Technical Committee has made good progress in all of its fields of endeavor. This year for the first time, every sub-committee of Larry's group will have met at a carefully selected, pre-determined time before or during this annual meeting to conduct important sub-committee business. These have been or will be productive meetings. The entire Technical Committee continues, in accordance with the lofty traditions of the past, to serve our industry well and unselfishly. For detailed accounting of this important work, plan to attend the concurrent technical sessions tomorrow and most importantly, be sure to be on deck for the Wednesday morning session. You will feel better about the future of our industry if you do.

As you will hear from Tom Binford at our business meeting later today, membership equals our all-time high. It's acknowledged by your board that much work remains in the membership field, for the Institute's purse strings are mainly manipulated by our membership efforts. Your devoted and faithful treasurer, Art Daniel, will tell you tomorrow, too, that if the Institute's services are to be increased then there is real need for increased Institute income—and there is no better source than new member's fees.

VICE chairmen M. L. Carter (Southwest) and R. S. Barnett (Texaco) chat with L. C. Brunstrum (Standard of Indiana), Technical Committee Chairman.

BRUNSTRUM meets newly-elected director H. B. Elliott (Atlantic) who assumed the vacancy left by director G. Landis, retired.

It's hoped that each of you will agree with me that our board committees have kept our continuing membership service activities at the same, high satisfactory level that has characterized past regimes. To wit:

1. Ed Campbell has seen to it that as an industry journal, our NLGI SPOKESMAN has no peer. It can become even better if we can someway increase advertising income to overcome ever-increasing publishing, printing and handling costs.

2. The annual Production Survey under the guidance of Tom Shaffer was completed on an improved basis and much thought is being given to further desirable refinements. Although there's general satisfaction within your board about participating levels, it's thought that there is room for improvement. This then is a plea for every active grease manufacturer to "pull his share" of this important load and develop a responsive reply to this year's new questionnaire (Production Survey). The more complete the participation, the more satisfactory the results.

3. Close NLGI liaison with the Petroleum Packaging Committee has been maintained by Bill Magie which service has repeatedly pointed the way toward interesting savings through the use of lighter gauge containers and through improved packaging and package handling methods. Here again is a field that will be capably covered later in this meeting with a well-prepared paper by the dean of the Petroleum Packaging Committee, Fred Langner.

4. The Chassis Lube Committee has worked long and hard to combat the obstinate, previously men-

CANADIAN director S. C. M. Ambler (British American) and F. W. Minor (Sinclair). Both were re-elected to the NLGI Board of Directors in Chicago.

tioned problems we're facing in Detroit. For the first time, regular bulletin mailings, patterned after those made by R. Cubicciotti's successful API Lube Committee Motor Oil Study Panel "Operation Bootstrap," have been made for the first time to all NLGI members and to other key industry people. And don't miss the presentation of the Chassis Lube Committee by its chairman, Jack Lane, to be given during our business meeting this afternoon. It's promised that you will find it interesting, challenging and rewarding.

5. As our publicity chairman, Bill Saunders has kept a steady stream of favorable NLGI publicity going to the various journals of our industry. Our over-all industry reputation continues to be a good one.

6. Through the hard-hitting work of our executive office staff, guided by our general manager, T. W. H. Miller, sales of our movie "Grease, The Magic Film" have been kept at a satisfactory level. Showings using the office copies have been and are being regularly booked. Our movie continues to be an effective spokesman for our industry and this activity continues to be our most important marketing effort.

7. Most important of all, your vice-president and Program Committee chairman, Frank Hart, has woven together the biggest and best Annual Meeting in history. Frank has taken great pains to see that this meeting, more so than ever before, will create for each of us the opportunity to discuss among ourselves, under conditions that should promote beneficial results, the many problems of our industry. Frank recognizes, as all of us do, that our problems are big ones, but big men working together through the medium of this Annual Meeting can overcome them. If you could but see the stack of correspondence which Frank has generated in support of or in promotion of this meeting, notwithstanding the hours of thought and study that preceded such correspondence, you would realize what a big contribution he has made this year. The Annual Meeting should always be the highlight of the NLGI year and it's confidently predicted that this year will be no exception. And to touch lightly upon another item of program committee business, based upon the comments many of you have made to me personally, and with no affront to our Chicago friends, you'll be happy to know that Frank has engineered a change in the long-standing policy covering Annual Meeting locations. The NLGI Annual Meeting will now leave Chicago every other year with definite plans having been made for the 1961 meeting in Houston and for the 1963 meeting in New York City.

So much for the past, how about the future—and it's the future where our most serious concern will always exist. What do the "Sixties" hold for our industry—how can we meet the challenges and the road blocks that will be thrown before us? Fortunately for me, again through the energetic efforts of Frank Hart, followed by the kind and generous acceptance of Charlie Guzzo, we have one of the most capable, experienced "men of action" the petroleum industry has ever produced to deal with this subject. It's been my privilege to read and study an advance copy of Mr. Guzzo's paper and believe me, he has effectively dealt with the future challenge of our industry. He's done this in the

VETERAN grease men F. E. Rosenstiehl (Texaco) and W. H. Saunders (International Lubricant) were re-elected. Not shown: G. A. Olsen and N. D. Williams.

same characteristically intimate, hard-hitting manner for which he has become so well known. Therefore, for our glance toward the future, it's hoped that you will agree with me that it makes sense for me to acquiesce in favor of Mr. Guzzo. You've got a real treat in store when he stands before this rostrum in a few short moments and, therefore, there will be no effort by me, ineffective as it would probably be, to steal his thunder.

These busy two years in NLGI office are quickly drawing to a close. My sincere thanks goes to all of those who have contributed so wholeheartedly to the projects of this regime. To Tom Miller and his Kansas City office staff, to every member of the hardest working, most conscientious board with whom it has been my privilege to work and especially to the various committee chairmen, and most importantly to Frank Hart for his program work, and to each of you without whose support the NLGI would fold and crumble, my sincere thanks and appreciation.

In conclusion, let's all remember that in our complicated, free enterprise society, the very roots of our business endeavors go even deeper than industry levels. With the great series of TV debates and the energetic campaigning by both of our major parties, all of us should be more familiar and conversant than ever with the big issues facing our nation. It's realized that everyone in this room will give such issues their serious thought and study and vote their convictions on that fateful day next week. But each of us should do even more—if our convictions are strong enough, and if we feel strongly enough about them, then we should make every attempt to influence those with whom we work, play and study—we should make an honest attempt to influence them to vote for those whom we think will best serve the future of our country. These are confusing, frustrating times. The stakes are big. Each of us has a tremendous responsibility for the long-range welfare of our country and there will be no better time to face up to it than in the seven days ahead. Our industry will only be as successful and as productive as the society in which it operates. World-wide conditions must be favorable if our industry is to make satisfactory progress in the important foreign areas. Sitting in this room with us now are delegates from foreign countries that we can influence. Perhaps we can convince them that we live in a God-fearing country—that we are people standing staunchly and sincerely for the cause of freedom around the world. Our industry problems are, and will continue to be, big ones but let's not permit them to totally obscure the big, important, ambitious goals that all of us are rightfully striving for as individuals and as a nation. Ours is the business of reducing friction. The sparks of world-wide and nationwide conflicts indicate that there's a tremendous market for our products—not just those that flow from our plants—but those that flow from our hearts. Everywhere you look there is a real need for friction-reducing efforts—let's call it a need for a grease job and let's make them available. And the manner with which we handle our ballot next week can be a big step in this direction. As my final plea, vote as you please, but please vote!

May I thank each of you again for this opportunity to make at least a partial payment against the accumulated back rent I owe for the space I've selfishly occupied in the grease business during my entire life time. It's been a privilege and a pleasure I'll never forget. Thank you! ■

CONCLUSION of his term is signified at the Annual Banquet when H. A. Mayor, Jr., who authored the address accompanying these pictures, turns the gavel over to the president-elect F. R. Hart, seated at the right. Mrs. Hart is seated to the right of NLGI's new chief executive, the Institute's 28th president.

NLGI 1960-61
Officers and Board of Directors

President

F. R. HART
Standard Oil (California)

Vice-President

C. L. JOHNSON
Jesco Lubricants Co.

Secretary

T. F. SHAFFER
Shell Oil Company

Treasurer

A. J. DANIEL
Battenfeld Grease and Oil Corp., Inc.

F. R. Hart is the 27th president of the National Lubricating Grease Institute—the supervisor of industrial and marine lubricants for the Standard Oil company of California, San Francisco, was elected to head NLGI next year during the annual meeting at the Edgewater Beach hotel in Chicago, November 1. He had previously served as vice-president and program chairman.

Vice-president of the Institute is C. L. Johnson, president of Jesco Lubricants company, Kansas City. He had previously served as secretary.

T. F. Shaffer, manager, industrial products department, Shell Oil company, New York, was elected secretary. Serving as treasurer for his ninth consecutive term is A. J. Daniel, president of Battenfeld Grease and Oil corporation of Kansas City. L. C. Brunstrum of Standard Oil company (Indiana), Whiting, Indiana, was reappointed to his second term as chairman of NLGI's technical committee.

Seven directors re-elected to the board for three-year terms include Daniel and Shaffer, as well as S. C. M. Ambler, British American Oil company, Ltd., Toronto; G. A. Olsen, Sunland Refining corporation, Fresno, California; F. E. Rosenstiehl, Texaco, Inc., New York; F. W.

Re-Elected Directors . . .

S. C. M. AMBLER
British American Oil Co.

G. A. OLSEN
Sunland Refining Co.

F. E. ROSENSTIEHL
Texaco Inc.

F. W. MINOR
Sinclair Refining Co.

W. H. SAUNDERS, JR.
International Lubricant Corp.

New Directors . . .

N. D. WILLIAMS*
Pure Oil Company

H. B. ELLIOTT
Atlantic Refining Co.

*Photo not available

Technical Committee

L. C. BRUNSTRUM
Chairman

M. L. CARTER
Vice-Chairman

R. S. BARNETT
Vice-Chairman

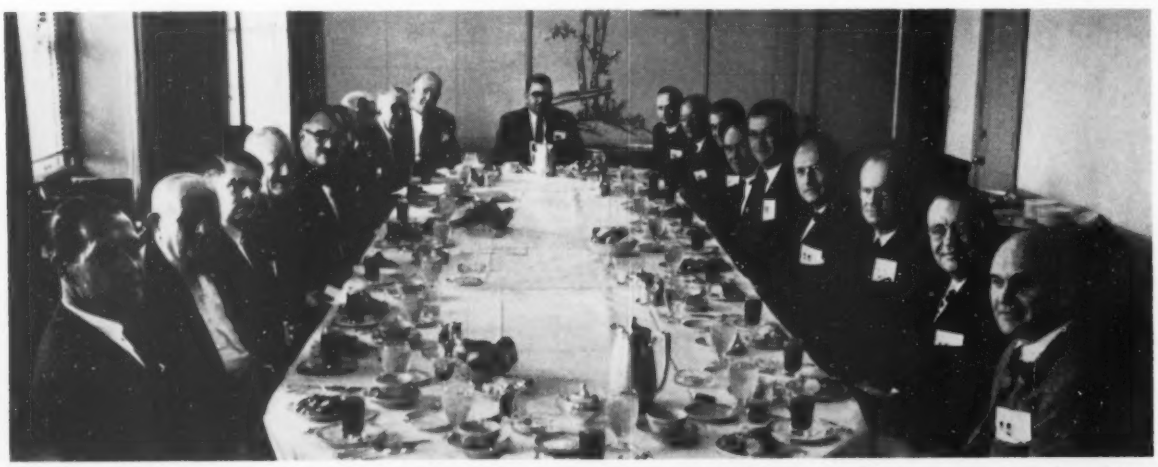
Minor, Sinclair Refining company, New York; and W. H. Saunders, Jr., International Lubricant corporation, New Orleans.

Elected to shorter terms to fill vacancies on the 21-man governing body were H. B. Elliott of Atlantic Refining company, Philadelphia, who will assume the two remaining years of George Landis, Atlantic, retired; and N. D. Williams of Pure Oil company, Palatine, Illinois, who will assume the one remaining year in the term of A. G. Griswold, Cities Service, resigned.

Members of the board and the executive committee currently serving terms in addition to those mentioned include: W. W. Albright, Standard Oil company, Chicago; T. W. Binford, D-A Lubricant company, Indianapolis; E. W. Campbell, Gulf Oil corporation, Houston; J. J. Coates, Esso Standard division of Humble Oil & Refining company, Pittsburgh; R. Cubicciotti, Sonneborn Chemical & Refining corporation, New York; J. W. Lane, Socony Mobil Oil company, New York; G. E. Merkle, Fiske Brothers Refining company, Newark; and W. M. Murray, Kerr-McGee Oil Industries, Oklahoma City.

Appointments of vice-chairmen of the technical committee include M. L. Carter of Southwest Grease and Oil, Wichita, serving his second term, and R. S. Barnett, Texaco, Beacon, New York, who has assumed the position vacated by M. J. Pohorilla, Kendall Refining company, Bradford, Pennsylvania, resigned.

NLGI's governing body meets at quarterly board meetings to decide the affairs of the Institute. The board will gather at Detroit in February, Hollywood Beach, Florida in May, and New York City in September. It will meet twice in October, during the 29th Annual Meeting in Houston. National offices for the Institute are in Kansas City. T. W. H. Miller is general manager. ■



NLGI's Board of Directors at the November 1 luncheon and meeting. From the left: Elliott, Johnson, Ambler, Campbell, Shaffer, Rosenstiehl, Daniel, Murray, Hart, and Mayor presiding. Coming down the table: Miller (general manager), Magie, Albright, Merkle, Coates, Lane, Saunders, Minor and Brunstrum (ex officio, as chairman of the Technical Committee). Members of the Board not shown: Cubicciotti, Olsen and Williams.

An Interpretation of

NLGI'S 1959 PRODUCTION SURVEY

By: T. F. Shaffer
Shell Oil Company

THE GROWTH in popularity of the lithium soap greases continues to increase and the more than 202 million pounds produced in 1959 represents 34.8 per cent, or over one-third of the total grease produced in the United States. While this growth was evidenced by a twenty-million-pound increase in production over 1958, which was 22 million pounds over 1957, the increase was only slightly greater than the proportionate increase of the total grease produced in 1959 versus 1958. The 1958 increase was very significant in that it occurred in a recession year which saw total production decline by eight per cent from the year before. Total United States grease production in 1959 reached a new high of nearly 583 million pounds, which eclipsed the 1957 production figure by one million pounds.

This upturn in production is very encouraging in view of the trend toward incorporating fewer grease fittings on the automobile chassis by the car manufacturers.

Calcium soap greases ranked a very close second in

SUMMARY OF TOTAL POUNDS PRODUCED — UNITED STATES
1959, 1958 AND 1957

	Pounds Produced			*Per Cent*		
LUBRICATING GREASES	1959	1958	1957	1959	1958	1957
1. Aluminum Soap	21,818,884	21,275,526	27,142,543	3.74%	3.97%	4.66%
2. Calcium Soap	201,088,543	179,708,385	218,844,369	34.50	33.56	37.61
3. Lithium Soap	202,928,917	182,457,197	160,462,383	34.82	34.07	27.58
4. Sodium Soap	114,407,746	113,570,809	128,859,083	19.63	21.21	22.15
5. Other Soap	20,164,128	19,874,925	28,680,446	3.46	3.72	4.93
6. Non-Soap (Inorganic Thickener)	22,452,003	18,597,992	17,891,004	3.85	3.47	3.07
TOTAL	582,860,221	535,484,834	581,879,828	100.00%	100.00%	100.00%

TOTAL POUNDS OF FLUID GEAR LUBRICANTS PRODUCED	*Pounds Produced*		
	1959	1958	1957
	507,667,875	495,298,609	483,999,270

ANALYSIS OF REPLIES — UNITED STATES
1959, 1958 AND 1957

	1959	1958	1957
Total questionnaires mailed	64	64	63
Total replies received	50**	47*	48*
Per cent return	78.13%	73.43%	76.19%

* One reply reported no production data
** Two replies reported no production data

popularity with 201 million pounds being produced in 1959 for 34.5 per cent, also a little over one-third of the total grease produced. This 1959 increase of 21 million pounds over 1958 represents a strong comeback in popularity, since 1958 production was 39 million pounds less than in 1957.

Non-soap (inorganic thickener) type greases, although representing only 3.85 per cent of the total grease produced, continue to gain in favor; the 1959 production of 22½ million pounds being nearly four million pounds greater than 1958, which in turn was nearly one million pounds greater than 1957.

The sodium, aluminum and other soap-type greases seem to be declining in popularity, since, although grease production in 1959 was 8 per cent greater than in 1958, production of these greases was essentially the same in 1959 as in 1958, and production in 1958 was about 30 million pounds less than in 1957.

Production of fluid gear lubricants continued to increase, reaching a new high of over 507 million pounds, a 2½ per cent increase over 1958, which in turn was 4½ per cent over 1957.

These trends in the production of grease and gear lubricants become evident after study of the results of the recent survey sponsored by the National Lubricating Grease Institute. This survey of the 1959 production of lubricating greases and fluid gear lubricants in both the United States and Canada is the third of its kind to be conducted by the management services of Ernst and Ernst, certified public accountants. Similar surveys were made in 1958 and 1957. As before, all questionnaires came from Ernst and Ernst and the replies were reported to them. No information from an individual member reporting company was made available to another company, nor to the Institute officers nor management. Only a final compilation was reported to the Institute office which has since distributed it to the membership. The professional integrity of Ernst and Ernst is our guarantee that the results are as accurate as the data submitted and that complete anonymity has been preserved.

Sixty-four questionnaires were mailed to Active members and replies received from 50 for a return of 78.1 per cent. This is the highest percentage return for the three years and it is hoped that a return of over 80 per cent may be achieved next year. This would increase the accuracy of this survey and the value of the trends developed from the production figures. While it is believed that the grease production figures reported represent almost all United States domestic production, since members in the NLGI represent about 95 per cent of the total production, it is estimated that the reported production of gear lubricants is not more than

CLASSIFICATION OF RETURNS ACCORDING TO SIZE

LUBRICATING GREASES			
Number of replies reporting production of:			
1 to 1,000,000 pounds	9	9	11
1,000,001 to 5,000,000 pounds	17	12	14
5,000,001 pounds and over	24	26	23
Total replies received	50	47	48
FLUID GEAR LUBRICANTS			
Number of replies reporting production of:			
No production data reported	4	2	6
1 to 1,000,000 pounds	12	14	13
1,000,001 to 5,000,000 pounds	14	11	11
5,000,001 pounds and over	20	20	18
Total replies received	50	47	48

SUMMARY OF TOTAL POUNDS PRODUCED — CANADA
1959 AND 1958

LUBRICATING GREASES	*Pounds Produced*		*Per Cent*	
	1959	1958	1959	1958
1. Aluminum Soap	1,265,818	288,785	3.94%	.88%
2. Calcium Soap	17,305,903	17,602,914	53.80	53.88
3. Lithium Soap	3,541,218	2,454,451	11.01	7.51
4. Sodium Soap	8,539,822	9,598,733	26.55	29.38
5. Other Soap	1,467,969	1,622,340	4.56	4.97
6. Non-Soap (Inorganic Thickener)	44,009	1,105,297	.14	3.38
TOTAL	32,164,739	32,672,520	100.00%	100.00%

	1959	1958
TOTAL POUNDS OF FLUID GEAR LUBRICANTS PRODUCED	24,864,899	31,963,603

ANALYSIS OF REPLIES	1959	1958
Total Active members mailed questionnaires	6	6
Total replies received	6	6
Per cent return	100.0%	100.0%

60 per cent of the total. This is because many compounders and blenders are not Active members of the Institute, and thus their production of gear lubricants is omitted from the survey.

The rules and definitions used in the survey remain the same as in the previous two surveys, namely, that production figures, rather than sales figures, should be reported, that members should be guided by the ASTM definition for lubricating grease, and that grease production should be reported by the type of thickener employed.

This is the second year that the survey included our Canadian friends and their response was 100 per cent. A total of six questionnaires were sent out and six replies received, the same as last year. In the Canadian economy calcium soap greases are by far the most popular amounting to 17.3 million pounds, or 53.8 per cent of the total. Sodium soap greases, while still accounting for 26.6 per cent of the total, declined one million pounds to 8½ million pounds, while the lithium soap greases increased one million pounds to 3.5 million pounds, or 11 per cent of the total. Total grease production in 1959 declined about one-half million pounds, to 32.2 million from 32.7 million pounds in 1958.

The 1959 production of fluid gear lubricants was only 24.9 million pounds, which represented a marked decline of seven million pounds from production in 1958. This decline may have been caused by recent recommendations of car manufacturers calling for the elimination of the semiannual drain and refill of transmissions and differentials, possible changes in the economic situation, or increased popularity of the automatic transmissions which utilize torque converter fluids. ■

About the Author

T. F. SHAFFER *is manager of the industrial products department of Shell Oil Co. Active in NLGI, he has been a member of the board of directors since* 1958 *and has served as chairman of the membership and survey committees. He has also been a member of the* SPOKESMAN *advisory, executive and chassis lubrication committees, as well as representative of the NLGI-API joint container committee. Mr. Shaffer was elected secretary of NLGI at the annual meeting just concluded in Chicago.*

1957
1958
1959
1960 SURVEY

Annual Compilation of U. S., Canadian Production to be Taken

Introduction of the fourth annual production survey, for production during the current year, 1960, will begin in mid-December. NLGI Active (manufacturing) members will be asked to report their production in pounds of fluid gear lubricants and lubricating greases. The December mailings are traditionally detailed explanations and sample questionnaires.

In January, U. S. and Canadian Actives will be sent official questionnaires. As in the past, the data will be broken down into six soap types of lubricating greases and total poundage of fluid gear lubricants.

Handling the survey will be the management services division of Ernst & Ernst, national certified public accounting firm—the organization which established the procedures of the first (1957) survey. E&E has managed this service ever since, including the 1958 and 1959 compilations.

Besides the valuable information the survey discloses, part of the success of this relatively new service is that it is maintained in such a fashion that the production of participants is anonymous . . . mailings are made en masse to all Actives, who voluntarily respond to the gathering agency, with or without identification. In this fashion the NLGI production survey for 1957 began with a whopping 76 per cent participation, which has since grown to over 78 per cent returns last year. Canadians have been 100 per cent in the two years, 1958 and 1959, they have participated.

While more than 78 per cent returns is a figure to be proud of, there will be a drive to get the remaining members to offer their yearly totals, in order to make the survey even more accurate. Like the official questionnaires, promotional data to urge participation will be mailed to all Actives, as there is no way of telling who is not sending back their poundage totals.

Almost three months are allowed Actives to compile their figures, before the March 31 deadline. The gathering agency then submits totals to NLGI's national office in mid-April. Distribution to all four classes of membership is made the same day of delivery to the Institute.

As the gathering agency for a number of surveys of various industries, the reputation of E&E is the assurance that replies to the NLGI survey are used for tabulation, then destroyed. Unmarked questionnaires are sent to Actives in duplicate . . . the member keeps one copy with his data on it for comparison, when the study is released.

With each succeeding survey, the historical value and knowledge of trends become more pronounced. Although almost all of Canadian and the great bulk of United States production is shown, the unknown fourteen firms not supplying poundage will be urged (anonymously) to begin their contributions in order that the survey will truly reflect the entire industry.

When the 1960 production survey is issued to the membership, it will not only show the pounds produced for this year, but shown alongside will be the yearly totals for the other three years. The historical significance can be of the utmost importance and all members are urged to offer their manufacturing data.

Structural Changes and Phase Transitions in Lithium Greases

By: R. M. Suggitt
Texaco Inc.

Presented at the NLGI 28th annual meeting in Chicago, October, 1960

I. INTRODUCTION

Many lubricating greases thickened by a crystalline soap undergo a series of reproducible phase transitions on heating. The phase changes are governed by the soap and may range in number up to as many as six for the sodium stearate:cetane system.[1] Basically these phase transitions signal molecular readjustments within the soap crystal induced by thermal agitation. As the temperature is raised the disorder within the crystal increases until no structure is left.

Alterations in the appearance and texture on heating or cooling a grease often accompany a phase transition. These changes, visible to the unaided eye, also reflect more fundamental changes in the structure of the thickening agent. The purpose of this investigation was to broaden our understanding of the relations between soap composition and phase transition behavior and how they, in turn, affect the development and

mechanical stability of the thickener structure. This increased knowledge can be valuable in selecting processing conditions as well as in deepening our understanding of the changes in grease properties with temperature.

In this study grease systems thickened by a series of lithium fatty acid soaps were used to shed light on how changes in the fatty acid component could affect properties. The fatty acids selected (capric, myristic, stearic and behenic) were ten, fourteen, eighteen and twenty-two carbon atoms in length.

The phase transition temperatures and their relative heats of transition were determined for grease systems thickened by these lithium soaps. With these phase transition temperatures as a basis, grease samples were subjected to various thermal treatments and their soap structures were examined by electron microscopy. In this way the changes in soap particle morphology that accompany the phase transitions could be determined.

Vold has studied the phase transitions of a series of sodium soaps differing in the chain length of the fatty acid.[2] These sodium soaps are characterized by a large number of phase transitions. In the case of the lithium soaps, no comparable study of the effects of fatty acid chain length has been found in the literature. The phase changes in the lithium soaps studied[3, 4] are fewer in number and those that do take place are spaced more widely in temperature than for the sodium soaps. For this reason greases thickened by lithium soaps of the straight chain fatty acids were regarded as well suited for a study of the effect of chain length on the phase transition temperatures and of the structural changes that accompany them.

II. EXPERIMENTAL

A. Materials

The soap:oil mixtures were formed in a small kettle by saponifying the fatty acid with lithium hydroxide solution in the presence of an equal amount of mineral oil. The products were thoroughly dehydrated at 300°F and additional oil was added on cooling. Commercially available fatty acids were used without further purification. In Table I, the available test information on these materials is listed to provide an indication of their purity. The oil used throughout this study for the preparation of greases was a naphthenic distillate fraction with a viscosity of 314 Saybolt Universal seconds at 100°F.

B. Equipment

1. *Differential Thermal Analysis*—The phase behavior of the soap:oil systems was obtained by differential thermal analysis. This technique has proved to be a rapid though sensitive and reliable method for determining the phase transition temperatures of lubricating grease.[3]

The apparatus consisted of a large steel block with two symmetrically placed wells. These small holes accommodated the sample and reference cells that were made of glass tubing. These glass cells with a capacity of about 3 cc each rested in the wells. Iron-constantan thermocouples were immersed in the sample and reference materials. Continuous records of the differential temperature and the reference cell temperature were obtained automatically.

Electrical heating wire was wound around the steel block and the temperature was raised by a steady wattage input. Though this procedure raised the temperature of the block at a slowly diminishing rate as the heat losses increased the method proved quite satisfactory. It is only necessary that the heating rate be uniform when a phase transition occurs. Over any 25°F range the heating rate in this system could be regarded as constant. The rate of heating over a specific temperature range could be easily adjusted by the wattage input of the continuous heater. Numerous tests showed that the heating phase transition temperatures of the systems under study were not dependent on heating rate.

Calibration of the equipment with materials of known melting points showed that the phase transition temperatures could be detected to within 2 to 3°F. However, quantitative heats of transition cannot be obtained with precision because of the variable rate of heating.

The same oil that was used to form the greases served as the reference cell material.

2. *Electron Microscope*—The RCA Type EMU-2 electron microscope was used to examine the soap phase of the greases. Specimens were prepared by de-

TABLE I
Tests on Fatty Acids

Fatty Acid	Behenic	Stearic	Myristic	Capric	Caproic
Number of Carbon Atoms	22	18	14	10	6
Neutralization No.	162	195	245	...	475
Saponification No.	163	195	247	325	477
Titer, °C	69.6	65.7	49.6	...	...
Iodine No.	3	2	2	...	0

TABLE II

Heating Phase Transition Temperatures of Lithium Soap Products

	Lithium Myristate			*Lithium Stearate*		
Per Cent Soap by Weight	100	38	10	100	38	10
Transition Temperatures °F	175	180	185	221	221	224
	390	375	377	350	338	337
	442	410	408	440	384	386
				—	401	395

positing a droplet of a dilute suspension of the soap in naphtha on a collodion covered specimen grid and leaching residual oil from the soap particle dispersion in a naphtha bath. Palladium shadowing was used to increase specimen contrast and examinations were carried out at 4000X magnification.

3. *Temperature Controlled Grease Worker*—In order to work greases under controlled conditions at elevated temperatures, a thermostated shearing apparatus was used that is similar in design to the ASTM Worker. The grease was enclosed in a cylinder and a shear plate containing twelve 1/16-inch orifices was stroked through the grease at about 25 double strokes per minute. The shear cylinder was heated electrically and the elevated temperatures could be controlled to within 1 or 2°F. Although this equipment has been used to shear greases under oxidizing atmospheres,[11] in these studies the gas vents were closed and no air or oxygen was allowed to contact the grease.

C. Phase Transition Behavior of Lithium Greases

In a detailed study Cox[3] has shown that the phase diagram of lithium stearate-hydrocarbon systems is essentially the phase behavior of the soap diluted by an inert fluid. Each soap-containing phase is continuous with a phase of the soap itself. Over a wide range of soap concentrations extending to the most dilute systems that could be studied, the temperatures of the heating phase transitions are nearly independent of soap concentration.

Cox was able to detect four phase transitions in the lithium stearate systems by a combination of differential thermal analysis (DTA) and optical microscopy. However, the two highest phase transitions were so close together in temperature that their separate detection by DTA was not always possible.

The phase transition temperatures of lithium myristate (C_{14} H_{27} O_2 Li) and lithium stearate (C_{18} H_{35} O_2 Li) systems at three soap concentrations as determined in this research are listed in Table II. Detailed phase diagrams of these lithium soap:oil systems were not developed. However, the data are consistent with the results of Cox. All the phase transitions noted in the soap:oil systems could be associated with phase changes in the soap itself and the temperatures of the heating transitions did not vary significantly between products with 10 and 38 per cent soap by weight. Only three phase transitions were consistently found in the 100 per cent lithium stearate. Greater resolving power by the DTA equipment may have demonstrated that the thermal effect highest in temperature consists of two transitions as shown by Cox. There was no evidence, however, of a fourth phase transition among any of the lithium myristate products.

In Table III the heating phase transition temperatures are listed for the four lithium grease systems. The lithium soaps with eighteen or twenty-two carbon atoms undergo four transitions while the soaps with ten or fourteen carbon atoms display only three phase transitions. The temperatures of the transitions change in a uniform manner. When the hydrocarbon chain of the fatty acid is lengthened, the temperature of the lowest phase transition rises while the temperature of the highest phase change decreases.

Although the heats of transition could not be measured quantitatively, the relative heat distribution

TABLE III

Heating Phase Transitions of Lithium Greases*

Lithium Soap	Caprate		Myristate		Stearate		Behenate	
Carbon atoms per molecule	10		14		18		22	
Phase Transitions	*Temp. °F*	*% of total heat*	*Temp. °F*	*% of total heat*	*Temp. °F*	*% of total heat*	*Temp. °F*	*% of total heat*
	116	7	180	18	221	21	230	32
	408	93	376	24	341	40	322	44
	432		410	58	384	39	366	24
					401		385	

*Based on data for systems with 38 per cent soap by weight.

FIGURE 1—Lithium myristate grease structure and maximum temperature of preparation: A, 365°F maximum; B, 375°F maximum; C. 385°F maximum.

among the phase changes could be roughly estimated. Table III also lists the percentage of the total heat of transition associated with each phase transformation. As the length of the hydrocarbon chain of these soaps is increased the relative portion of the total heat associated with the lowest phase change increases while the heats of the higher phase transitions decrease.

D. Soap Structural Forms and Thermal Treatment

The four products of 38 per cent soap in oil had been formed with a maximum temperature of 300°F. This temperature is in each case between the first and second heating phase transitions of the system. Generally the products were very soft but after the DTA evaluations they were hardened to a very stiff consistency. Electron microscopy revealed that each of the materials prepared at 300°F possessed a platelet structure. After the DTA evaluations the soap was subdivided into long, well-dispersed fibers. Forster, Kolfenbach and Leland[5] have reported this same observation for a lithium stearate:cetane system. However, the minimum temperature at which this solubilization of the soap could occur was not established.

To ascertain the temperature needed to get the fi-

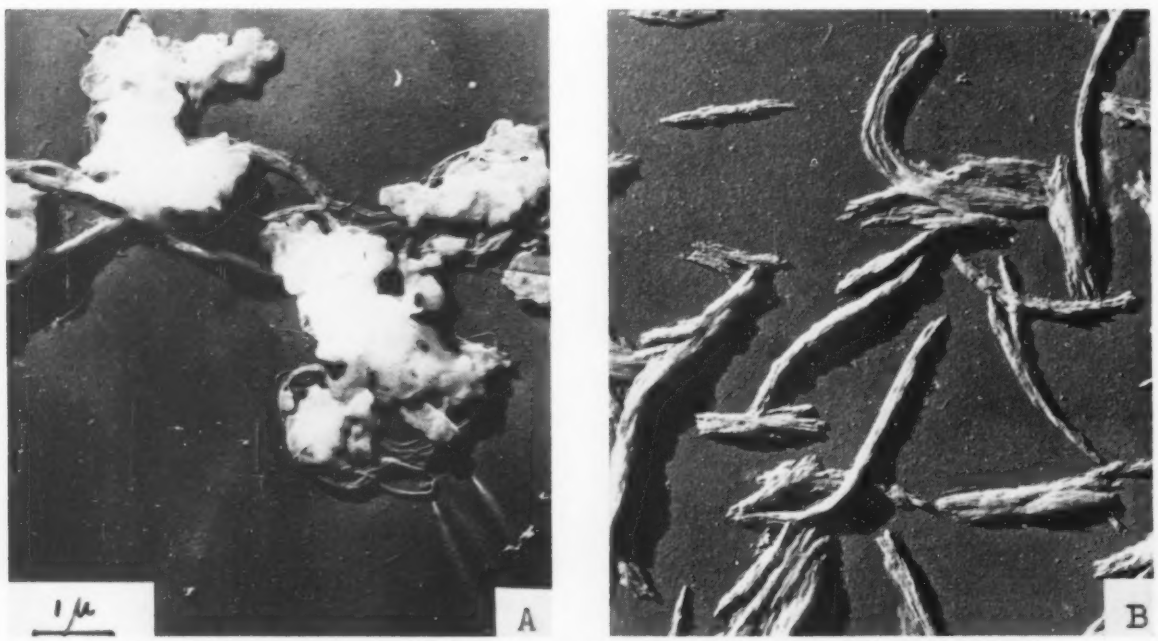


FIGURE 2—Lithium behenate grease structure and maximum temperature of preparation: A, 315°F; B, 340°F.

brous structure with the high gel strength, fresh samples of the soft grease were heated statically to maximum temperatures based on the phase transition studies. The DTA apparatus was equipped with a thermal regulator and the samples could be held within 1 to 2°F of any desired temperature for long periods.

The structures of the lithium myristate grease held without agitation for six hours at 365, 375 and 385°F and then cooled slowly are shown in Figure 1.

The structure, Figure 1A, and the consistency of the sample held at 365°F were not changed from the original grease properties. The flat platelets that characterize the original structure are retained and no hardening took place.

The sample heated to 375°F was hardened slightly. The electron micrograph, Figure 1B, shows that at this temperature the basic form of the original structure is still retained. However, some filamentation of the platelets is evident. This appearance suggests that the breakup of the original units is imminent at this temperature.

The second heating phase transition of this material was found to take place at 376°F. The soaking temperature over the six hour period varied from 374 to 376°F. Thus it is apparent that a temperature equivalent to that needed for the second phase transition was reached part of the time by this sample held at 375°F.

When the system is held at a maximum temperature of 385°F for six hours, which exceeds the level of the second phase transition, the platelets characteristic of the starting material are replaced by a fibrous structure; Figure 1C. At this temperature the lithium myristate is sufficiently solubilized by the oil to cause the breakup of the soap platelets. On cooling the soap remains in a subdivided form that gels the oil into a hard grease.

These electron micrographs show that to form a fibrous structure it is not necessary to melt the lithium myristate soap. Only a temperature in excess of the second phase transition on heating is needed. At this phase change the coarse lithium myristate soap platelets are filamented in one direction. The oil penetrates between the units and prevents them from rejoining upon cooling.

Studies with the other lithium soap greases show that a specific phase transition is also responsible for the development of the fibrous form of soap structure. In each case it is found that fibers are formed when the second heating phase transition is exceeded in the thermal treatment. In the case of lithium behenate this temperature is 322°F. Figure 2 illustrates the structures of two lithium behenate greases heated with stirring to maximum temperatures of 315 and 340°F respectively. The platelet structure of the original grease is still the main structural form when 315°F is the maximum temperature; Figure 2A. However, these platelets are replaced by fibers when the maximum temperature is raised to 340°F; Figure 2B.

Figure 3A, however, shows that a maximum temperature of 400°F is not sufficient to cause the filamentation of the lithium caprate soap because 408°F is the

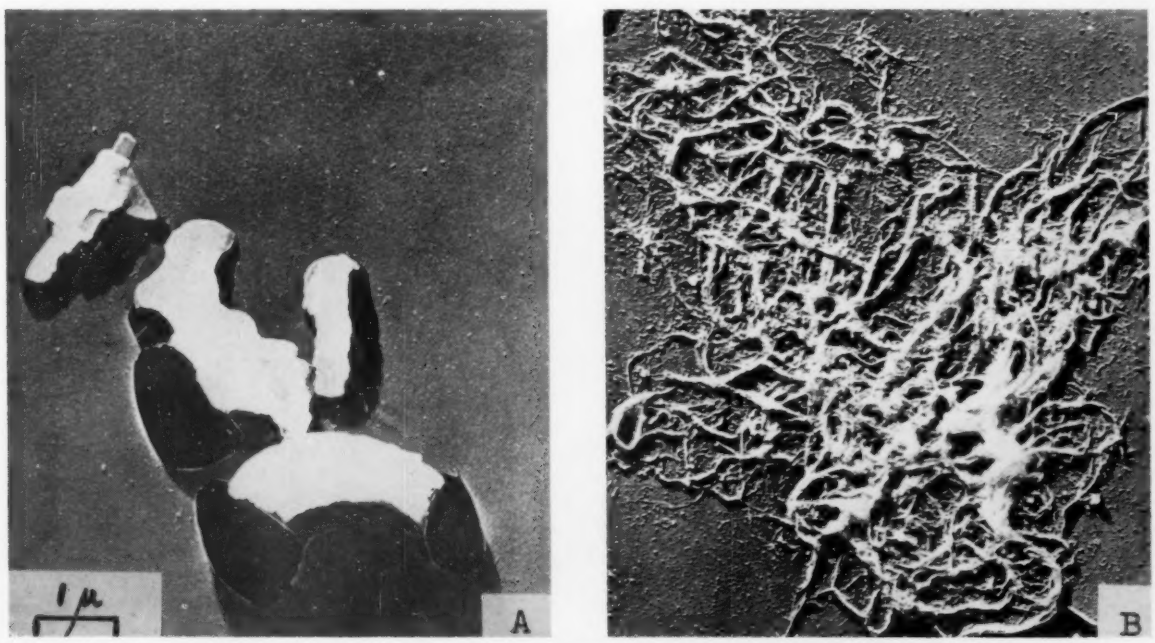


FIGURE 3—Lithium caprate grease structure and maximum temperature of preparation: A, 400°F; B, 440°F.

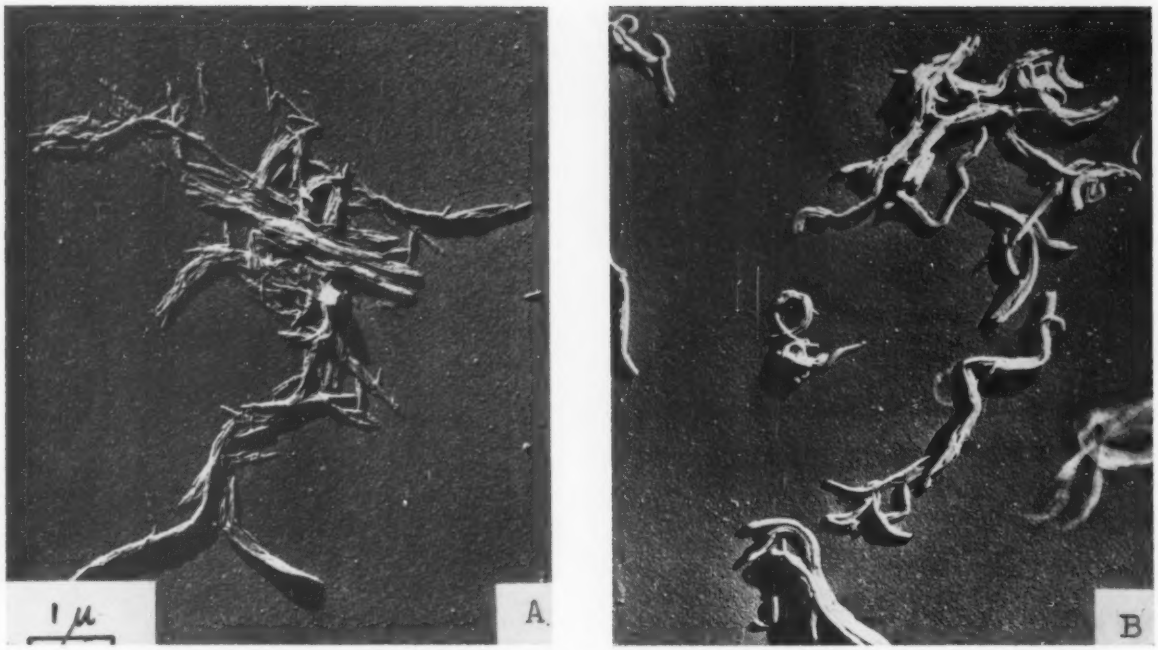


FIGURE 4—Lithium myristate grease structure and rate of cooling: A, quenched from 430°F to room temperature; B, cooled from 430°F at 1°F per minute.

temperature of the second heating phase transition. When the temperature is raised above this or above the 432°F phase transition, a fibrous structure is formed as shown in Figure 3B.

E. Dropping Point Temperature and Phase Transition Behavior

Although a fibrous structure is obtained when the temperature exceeds the second heating phase transition temperature only, the products are not melted by this thermal treatment. These samples retain their shape until a temperature approaching the value of the next higher phase transition is reached. The ASTM dropping point temperature is used to measure the temperature at which the grease releases a drop of material (oil or grease) from a standard cone. The dropping point temperatures of these lithium greases made with 10 per cent thickener are listed in Table IV. These temperatures fall short of the third heating phase transition by only a few degrees.

TABLE IV

ASTM Dropping Point Temperatures of Lithium Greases

Lithium Soap Thickener	*Drop Point °F.*	*Third Heating Phase Transition, °F.*
Caprate	416	432
Myristate	400	410
Stearate	378	384
Behenate	365	366

F. Structure and Fatty Acid Component Chain Length

When the temperature is raised above the second phase transition, the maximum value is found to have little effect on the final structure of these lithium greases. Their structure is dependent mainly upon the cooling program. For example, it has been found that the rates of cooling and the use of holding periods at specific temperatures affect both the structure[6] and the properties[7] of lithium stearate grease.

While a detailed study of the effects of cooling programs on structure is beyond the scope of this study, one of the objectives of this investigation was to make a comparison of the fiber structures of the lithium greases varying only in fatty acid component. To simplify preparation conditions shear was omitted and the samples were cooled statically. The electron micrographs in Figure 4 show the structures of two 10 per cent lithium myristate greases cooled at two rates. One, Figure 4A, was quenched rapidly from a melted state to room temperature and the other, Figure 4B, was cooled at 1°F per minute. When the grease is cooled very rapidly, the fibers appear filamented and fragile. When they are formed more slowly, the fibers appear more uniform in surface structure.

The structures of lithium stearate and lithium behenate greases prepared under the same cooling conditions are very similar to the lithium myristate structures shown in Figure 4. The main variation is in the fiber size distributions which are listed in Table V. As the

TABLE V

Fiber Size of Quenched and Slowly Cooled Lithium Greases, No Agitation

Lithium soap	*Carbon atoms per soap molecule*	*Quench Cooled*		*Cooled 1°F/Min*	
		Length microns	*Width microns*	*Length microns*	*Width microns*
Myristate	14	0.5-3	0.03-0.1	0.5-2.5	0.06-0.15
Stearate	18	0.4-5	0.05-0.15	0.5-3	0.08-0.15
Behenate	22	0.4-10	0.05-0.2	1-4	0.08-0.15

hydrocarbon chain length of the soaps is increased, the fibers increase in width and length. It is interesting to note that fibers up to ten microns in length are formed under these static cooling conditions.

G. Mechanical Stability of Structure with Temperatures

The effect of exceeding the temperature of the higher phase transitions results directly in the formation of a fibrous structure. The changes in soap form can be seen by examining samples treated under static conditions. However, the effects of the lowest phase transition on structure could not be determined by these static heating methods.

One effect on structure that may be tied in with this lowest phase transition is the change in mechanical stability with the temperature of working. Long fibers of these lithium greases appear more stable when sheared at a temperature above this transition. This dependence of structural stability on temperature was shown by shearing portions of a long fibered lithium behenate grease for eight hours at 140°F and at 275°F. Electron micrographs of the original grease and the products after shearing at these two temperatures are shown in Figure 5. The fibers after being worked at 275°F show no indication of having been shortened in length. After shearing at 140°F, almost no discernible fiber structure remained. The soap had been reduced to a finely-dispersed particulate state.

The ASTM penetration of the original grease after being worked 60 strokes at 77°F was 305. After the 275°F shearing treatment, the grease had hardened to a 199 penetration. The material worked at 140°F for eight hours had become semi-fluid.

A second system, a lithium myristate grease, when sheared at temperatures above and below (225 and 140°F) the lowest phase transition temperature (175°F) did not show a marked change from the original product in either structure or consistency. In this case, the fibers were approximately 1 micron in length and consequently, the structural breakdown that may occur at low temperatures was not detectable. Temperatures below 140°F could not be maintained in the controlled temperature grease worker because of frictional heating.

When lithium myristate grease is worked at room temperature in the ASTM Worker, a structural degradation is obtained. The fibers aggregate as shown in Figure 6. The structural units increase in both width and thickness. Since these fiber aggregates possess a smaller length to width ratio, the consistency of the grease should be softer.[8] In this case, the grease softened from an ASTM penetration of 292 to 371 upon receiving 100,000 double strokes in the ASTM Worker.

FIGURE 5—Lithium behenate grease structure and temperature of working: A, original grease; B, worked 8 hours at 140°F; C, worked 8 hours at 275°F.

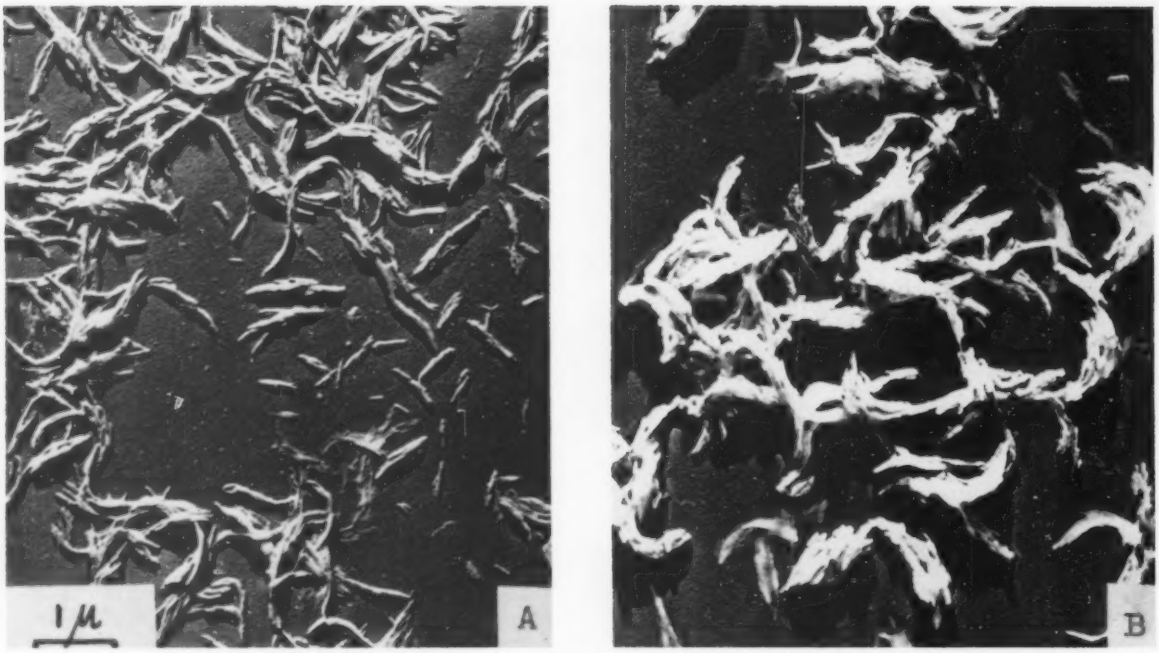


FIGURE 6—Lithium myristate grease structure: A, before being worked; B, after being worked 100,000 double strokes in the ASTM Worker.

H. Correlation of Phase Transition Behavior with Composition

The similarities in structural development for the four lithium greases infer that the phase transitions produce analogous changes in crystal structure. The types of crystal changes described by Cox can be used to identify the phase transitions in the other lithium greases. The thermal ranges of stability for the various heating phase transitions are plotted in Figure 7 as a function of the carbon chain length of the lithium soap. The phases are identified by the nomenclature of Cox.[3] These heating phase transition temperatures are almost independent of soap concentration of the grease.

As the hydrocarbon chain length decreases, the number of transitions is reduced. Although a stable grease could not be formed with lithium caproate ($C_6 H_{11} O_2 Li$) a soap:oil mixture was tested by differential thermal analysis. Only one phase transition, at 535°F, was found. Efforts designed to detect a phase transition at temperatures as low as 30°F were unsuccessful.

The cooling phase transitions are not always the same as those noted on heating. The temperatures of the highest and lowest phase transitions are similar to those found on heating but the intermediate phase transitions generally are supercooled from the values found on heating. The amount of supercooling of the second lowest phase transition can vary from a few degrees to nearly 100°F depending upon the concentration of the soap, the type of oil present and the amount of agitation.[3]

III. DISCUSSION

The variation in thermal stability of the phases when the hydrocarbon chain length of the soap is altered can be used to shed some additional light on the nature of these phase changes.

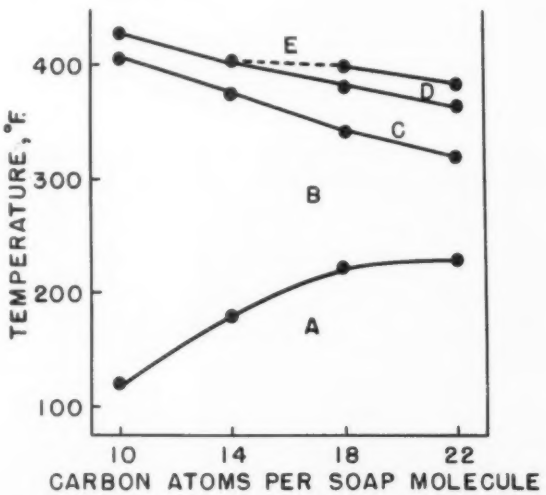


FIGURE 7—Temperature of equivalent phase transitions of lithium greases: A, crystalline soap II; B, crystalline soap I; C, waxy phase; D, liquid crystal phase; E, isotropic solution.

The long hydrocarbon chains of the soaps make it impossible for the soap to form a normal three dimensional ionic lattice. Only a two-dimensional layer lattice of the metal and carboxyl ions two molecules thick is possible. Layers of these lattices can build up a platelet structure.[9]

The attractive forces operating between adjacent soap molecules stacked in these two dimensional lattices are of two kinds. Along the paraffinic chains weak van der Waals forces prevail whereas in the ionic layer the much stronger coulombic forces are operative. Within this layer lattice, it is probable that the molecular packing along one axis is regulated by hydrocarbon contacts and by oxygen atom contacts along the other.

Vand and de Boer[10] have considered these two sets of forces in developing a theory of the intermolecular forces present in soap crystals. The main binding energy is derived from the ionic portions of the lattice. However, the ionic ends of adjacent soap molecules are not able to pack sufficiently close together to get maximum interaction. The ionic ends are forced apart by the repulsive forces built up in the hydrocarbon chains. The resistance to packing should increase as the hydrocarbon chain is lengthened and the distribution of forces would cause an increase in the intermolecular spacing of the soap crystalline lattices. Vand and de Boer have verified this theoretical prediction by X-ray diffraction studies on sodium soaps.

A similar enlargement of the intermolecular spacings would be predicted for the lithium soaps when the length of the hydrocarbon chain is increased. If the distance between the ionic portions of the lattice is increased, the bonding energy would be decreased. Those phase transitions associated with the disordering of the ionic lattice would be decreased in temperature and in heat of transition as the chain length of the hydrocarbon portion of the lithium soap is increased. The differential thermal analysis data show the transitions occurring at the higher temperatures behave in this manner (Figure 7).

The energy requirements for transitions that primarily involve the disordering of the van der Waals forces might be expected to increase as the hydrocarbon chain is lengthened. Since the lowest phase transition increases both in temperature and in energy this transformation is regarded as being due to some sort of disorder in the bonding of the hydrocarbon portions of the soap molecules.

On the basis of the thermal data the second and third phase transitions of these lithium soaps are regarded as marking disorder in the arrangement of the soap molecules within the ionic lattice. The second transition might then represent loss of order in one dimension and the third heating transition loss of crystallinity in the other. The electron microscope evidence suggests that the basic platelet structure is broken up at these second and third phase transitions. Cox[3] suggests that a two dimensional crystal is produced when lithium stearate is heated above the second phase transition. When the third phase transition is exceeded a one dimensional crystal is created. Upon heating above the fourth transition, an isotropic solution is formed. The thermal data for the other lithium soap systems are consistent with this picture except that in the cases of lithium myristate and lithium caprate the last two steps are combined.

IV. CONCLUSION

These studies have shown that phase transitions play an important role in understanding structural changes in lithium fatty acid soap greases.

Acknowledgment

The author wishes to thank Mr. H. M. Allred for making the electron microscope examinations and Dr. F. C. Toettcher for suggestions and discussion during this work.

References

1. Stross, F. H., and Abrams, S. T., *J. Am. Chem. Soc.*, *73*, 2825 (1951).
2. Vold, R. D., *J. Am. Chem. Soc.*, *63*, 2915 (1941).
3. Cox, D. B., *J. Phys. Chem. 62*, 1254 (1958).
4. Vold, R. D., *J. Phys. Chem. 49*, 32 (1945).
5. Forster, E. O., Kolfenbach, J. J., and Leland, H. L., NLGI Spokesman, Vol. 20, No. 3, p. 16 (1956).
6. Trapeznikov, A. A., Shchegolev, G. G., and Astakhov, I. I., *Izvest Akad Nauk S.S.S.R., Ser Fiz 23*, 777 (1959). See *Chem. Abstracts 53*, 20772 g (1959).
7. U. S. Patent 2,629,695.
8. Moore, R. J., and Cravath, A. M., *Ind. Eng. Chem. 43*, 2892 (1951).
9. Chwalow, M. L. E., *J. Phys. Chem. 57*, 354 (1953).
10. Vand, V. and de Boer, J. H., *Konikl Akad Wetenshap Amsterdam 50*, 991 (1947).
11. The apparatus is illustrated schematically in *Lubrication*, *31*, 82 (1945). ■

About the Author

R. M. Suggitt *graduated from the University of Toronto with a BA degree in* 1947. *He received a PhD in physical chemistry from the University of Michigan in* 1952. *He has been associated with Texaco Inc. since that time. A group leader at the Texaco research center, Dr. Suggitt has centered his interests in the fields of surface and colloid chemistry. He is a member of ACS, RESA and the Society of Rheology.*

Literature and Patent Abstracts

Composition

Barium Base Lubricating Greases

Worth in U.S. Patent 2,943,054 (assigned to Union Oil Co. of California) describes the manufacture of barium base lubricating greases from 12-hydroxystearic acid and containing 0.05 to 5 per cent of a boron ester compound as a stabilizer. The finished lubricants are said to have high dropping points, good reversibility and shear stability.

The boron esters are obtained by heating a mixture of orthoboric acid and glycols or polyglycols or glycerol esters of hydroxy fatty acids to 215 to 425°F. For example, a 50 per cent solution of such an ester in oil was prepared by heating a mixture of 4.5 per cent orthoboric acid, 45.5 per cent hydrogenated castor oil and 50 per cent of oil to 400°F. Upon cooling, this was a hard mass.

A lubricating grease was prepared by heating to 200°F 300 grams of 12-hydroxystearic acid and 400 grams of oil. To this was added 135 grams of barium pentahydrate and 50 ml. of water. The whole was heated for 20 minutes at 200°F before 2100 grams more oil was added gradually while heating to 330°F. During this heating and at a temperature of about 250°F, 85 grams of the boron ester concentrate described above was added.

The finished lubricating grease had a soap content of 12.4 per cent, a penetration of 131, a dropping point of 342, softened 20 points on a Shell roll test and was reversible on a hot plate.

A similar product is described in U.S. Patent 2,943,055, likewise credited to Worth, only in this case the stabilizing compound consists of the reaction product of one mol. of triethanolamine and between 1.4 to 1.7 moles. of orthoboric acid.

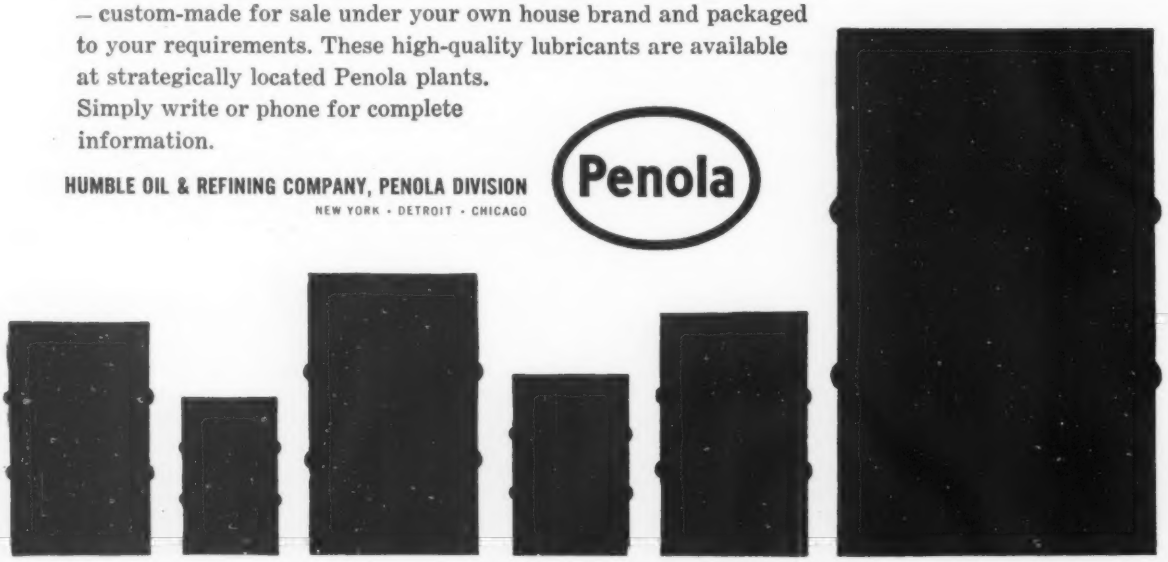
PENOLA INDUSTRIAL & AUTOMOTIVE LUBRICANTS

Custom-made, custom-packaged for you!

Penola is a dependable source for industrial and automotive lubricants – custom-made for sale under your own house brand and packaged to your requirements. These high-quality lubricants are available at strategically located Penola plants. Simply write or phone for complete information.

HUMBLE OIL & REFINING COMPANY, PENOLA DIVISION
NEW YORK · DETROIT · CHICAGO

Penola



Thus, a mixture of 60 per cent triethanolamine and 40 per cent orthoboric acid was heated at 220°F for 20 minutes to give a clear viscous liquid when cooled.

A lubricating grease was prepared as above except that 6.5 parts of the additive just described replaced the boron ester used in the first illustration and also 5 parts of phenyl alpha naphthylamine were included. A reversible lubricating grease having a penetration of 124, a dropping point of 352 and which hardened 11 points on a Shell roll test resulted.

The characteristics of the oil used were not given but it is stated that practically any type of oil can be used in these lubricants.

While not so stated, we can presume that the penetrations given are micropenetrations rather than standard ASTM penetrations.

Lubricating Greases Containing Fatty Acid Esters of Saccharides

In U.S. Patent 2,944,024 (assigned to Esso Research and Engineering Co.) Morway and Waddey describe a lubricating grease in which the thickener consists of 5 to 30 weight per cent of an ester of one mole of a disaccharide and one to three moles of a C_{12} to C_{32} fatty acid and five to forty weight per cent of an alkaline earth metal salt of a C_2 to C_6 fatty acid. The preferred ester is sucrose mono or distearate and the preferred salt is calcium acetate.

For example, 10 parts by weight of sucrose distearate were dispersed in 55.6 parts of lubricating oil, having a viscosity of 55 SUS at 210°F, by heating and stirring to 300°F. After this mixture had been permitted to cool to 100 to 120°F, 13.4 parts of hydrated lime were dispersed in the ester-oil mass. When a smooth slurry was obtained, 20 parts of glacial acetic acid were added while stirring. Almost immediately a heavy solid grease structure formed and the temperature rose to 180°F. Stirring was continued until the temperature began to drop, after which heating was resumed to bring the

HARCHEM
2-SL
BASIS FOR THE SOLUTION TO LOW AND HIGH TEMPERATURE LUBE PROBLEMS
Harchem 2-SL is a synthetic lubricant base that meets Mil-L-7808 specifications. For the lubrication of jet aircraft, missiles and their instruments, electrical systems and servomechanisms, 2-SL assures viscosity stability through temperature ranges from -65°F to 347°F. Excellent compatibility with oxidation inhibitors, minimum corrosivity and high load carrying ability are also characteristics of this lubricant base. Requests for further information will be promptly answered.
WRITE FOR BULLETIN OR CONSULT
CHEMICAL MATERIALS CATALOG PAGES 173-175
THE KEY TO
HARCHEM
BETTER PLASTICS
HARCHEM DIVISION
WALLACE & TIERNAN, INC.
25 MAIN STREET, BELLEVILLE 9, NEW JERSEY
IN CANADA: W. C. HARDESTY CO. OF CANADA, LTD., TORONTO

mass to 320°F. The product was then permitted to cool while stirring and at 200°F one part of phenyl alpha naphthylamine was added before further cooling to room temperature.

The finished lubricating grease had a dropping point above 500°F, penetrations of 275 worked and 290 after 100,000 strokes, a life in a bearing operating at 250°F and 10,000 rpm of over 1,300 hours. The product was insoluble in water and carried 15 weights on an Almen Test. The texture of the lubricant was smooth.

Lubricating Greases Containing Salts Of an Amidic Acid

Anhydrous lubricating greases having high dropping points and good shear stability are formed by thickening oils with metal salts of certain complex amidic acids. According to Nelson (U.S. Patent 2,947,696, assigned to Sinclair Refining Co.) 10 to 25 per cent of such thickeners are used.

The suggested acids can be made by slowly adding one mole of a diamine to each two mols of a dibasic acid dissolved in xylene, after which two mols of water are distilled off. Finally a monoamine sufficient to amidfy one of the acid groups is added. Thus, to two moles of sebacic acid in two-tenths of a mole of xylene all at reflux temperature was added slowly one mole of ethylene diamine. The mixture was heated until two moles of water were removed by azeotropic distillation. The resulting dicarboxylic acid diamide was then treated with one mole of octadecylamine to convert one of the acid groups to an amide. After one mole of water was removed by azeotropic distillation, the xylene was distilled off leaving the complex amidic acid.

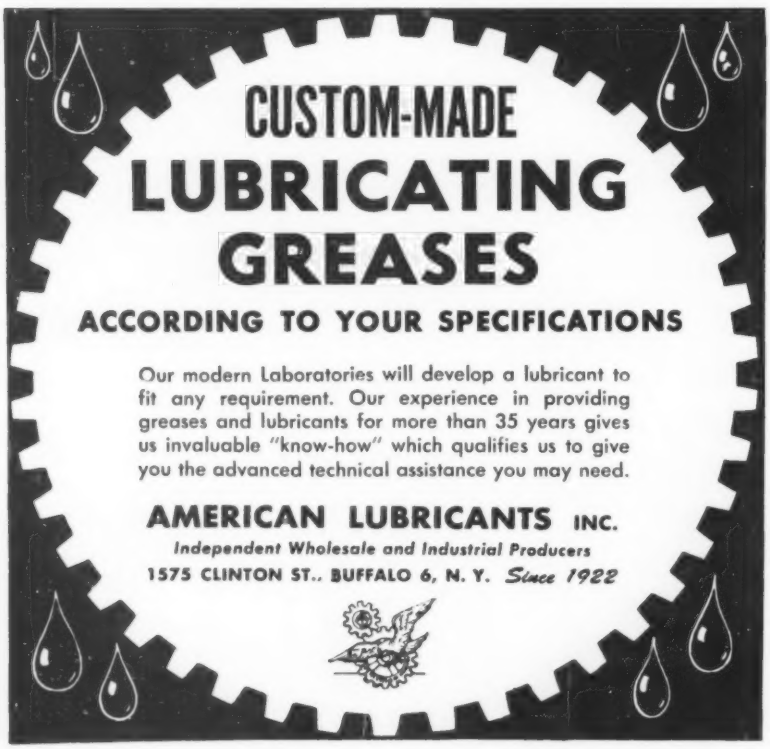
A lithium base grease was prepared from one pound of the above acid dispersed in four pounds of a conventionally refined coastal oil having a viscosity of 300 SUS at 100°F. To this mixture, heated to 270°F, were added 32 grams of lithium hydroxide monohydrate dissolved in 150 grams of water. The mass was mixed and heated to 360°F over a period of 1¼ hours. Heating was then discontinued and while stirring and cooling to 155°F, 3.7 pounds more oil were added. The lubricating grease, obtained by milling at 0.005 inch clearance on a Charlotte colloid mill, had a worked penetration of 320 and a dropping point of 495°F. The lubricant contained 11.5 per cent soap and was resistant to the action of boiling water.

Composition and Processing

Dye-Clay Base Lubricating Greases

Dupzyk and Woods in U.S. Patent 2,940,928, assigned to Shell Oil Co., describe lubricating greases in which the thickener consists of a mixture of certain dyes and a clay. Some of the advantages of such mixtures are that less dye is required for a given consistency of finished lubricant and also excessive hardening does not occur as it does with either clay base or dye base lubricating greases as the result of heating and cooling cycles. With the lesser amount of dye, less staining takes place and no doubt the cost is reduced.

The dyes suggested include indanthrene, indigo, copper phthalocyanine, etc. The preferred types of clay are those which have a high swelling capacity in water and also have a relatively high base exchange capacity, such as bentonites. When the lubricating grease must have water-resistant properties, the aqueous clay slurry is modified by the addition of one to two per cent by weight, based on the anhydrous clay, of a phosphorus acid. Either natural or synthetic oils can be used provided the fluid has the necessary characteristics to act as a lubricant under the proposed application conditions. The proportion of clay to dye is preferably restricted to ratios of clay to dye of one to four and about four to one.


CUSTOM-MADE
LUBRICATING
GREASES
ACCORDING TO YOUR SPECIFICATIONS
Our modern Laboratories will develop a lubricant to fit any requirement. Our experience in providing greases and lubricants for more than 35 years gives us invaluable "know-how" which qualifies us to give you the advanced technical assistance you may need.
AMERICAN LUBRICANTS INC.
Independent Wholesale and Industrial Producers
1575 CLINTON ST., BUFFALO 6, N. Y. Since 1922

The advantages claimed are not obtained by mixing an anhydrous clay thickened lubricating grease and an anhydrous dye thickened product. Rather water slurries of the two gelling agents are mixed with the lubricating fluid and the water is then removed by azeotropic distillation. The preferred azeotroping agents are alcohols such as methanol, ethanol, isopropanol, and butanol which are used in amounts equal to or up to ten times greater than the water. While less dusting will occur if the dye is added in the form of a water paste or slurry, the dry powder can be used.

For example, a lubricating grease was made from the following weight per cents: hectorite clay 4.2; phosphoric acid 0.25; indanthrene dye 3.4; and DC-550 silicone fluid 92.15. The clay was dispersed in water and gangue removed by centrifuging leaving a suspension containing 2 per cent of clay. The indanthrene dye was added in the form of an aqueous paste containing 1.6 per cent by weight of the dye. The phosphoric acid was then added and the mixture was stirred and heated to the boiling point of water to form a soft gel. Next, isopropyl alcohol equivalent to six times the amount of water present was added and then the silicone oil. The water and alcohol were then removed by azeotropic distillation and the resulting mass was passed through a three-roll paint mill.

This gave a lubricating grease with a worked penetration of 227 which changed to 330 after 100,000 strokes in a grease worker. The product absorbed 35 per cent water but had no washout with water at 100°F. The lubricant had a bearing life of 62 hours at 600°F.

Consumption

Chemical Week, June 18, 1960, pages 115, 116, 118, has the following comments in an article entitled, "New Engines Alter Car Chemical Market."

Production of lubricants, greases and fluid gear compounds climbed to over a billion pounds in 1959, representing a ten per cent increase over 1958. Sales in 1960 are estimated to be about eight per cent higher than in 1959.

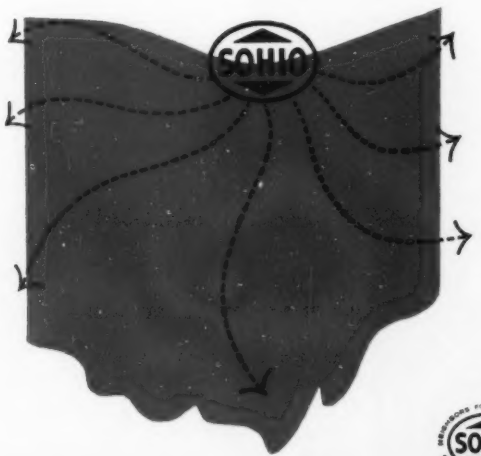
There is considerable talk about nonmetallic, nongrease filled bearings (for example, bearings made with Teflon). Some observers say that the cost will never be low enough to pose a real problem for lubricant marketers. Others are highly optimistic and believe that wide use of such bearings is imminent.

Compositions

Non-Soap High Temperature Lubricating Greases

According to Peterson (U.S. Patent 2,944,970, assigned to Shell Oil Co.) lubricating greases which remain plastic for extended periods in

Sohio brings you the quality stock oils you need . . . when and where you need them!



You're assured of prompt delivery of stock oils when you make Sohio your source of supply. That's because of Sohio's complete distribution system that brings stock oils to you *on time*, anyplace in the Midwest. And Sohio offers a complete line of high quality, dependable stock oils—paraffin or solvent—to completely meet the needs of any compounder or grease maker. Contact us now.

SOHIO

MIDLAND BLDG., CLEVELAND 15, OHIO

temperatures exceeding 400°F are formed by thickening high viscosity lubricating oils with colloidal gels of inorganic origin if there is included one to ten per cent of certain salicylic acid derivatives. Illustrative of these latter compounds are methylene bis(salicylic acid) and zinc di(isopropylsalicylate).

The oils recommended for such high temperature lubricating greases are bright stocks containing less than 15 per cent by weight of aromatic hydrocarbons and having viscosity ranges of 1250 to 11,000 SUS at 100°F. The inorganic thickeners may include clays, fine silicas, etc.

To indicate the benefit derived from the use of the additives in question, a lubricating grease consisting of a bright stock containing 10 per cent of silica aerogel was chosen. A film of this product, approximately 0.013 inch in thickness, spread on a sanded steel plate and heated in an oven for six hours at 200°C formed a hard lacquer. Addition of 5 per cent of either methylene bis(salicylic acid) or zinc bis(isopropylsalicylate) followed by the same oven exposure resulted in films which were substantially unchanged.

In another test, a lubricating grease was chosen which consisted of a bright stock gelled with 10 per cent of a hydrophobic onium clay. This product was used in a bearing test in which each cycle consisted of operating four hours at ambient temperature, raising the temperature to 400°F for ten hours, stopping the machine for ten hours and repeating the cycle. Failure involved a high noise level or stalling of the rig. This clay base lubricant lasted only two cycles on such a bearing test. After the addition of ten per cent of magnesium (diisopropyl salicylate) to the lubricating grease, the test life was extended to ten cycles.

Application

One-Shot Grease System

National Petroleum News, July 1960, page 159, describes a One-Shot chassis lubricating system which will permit greasing while the gas tank of a car is being filled. The estimated present cost of the unit is about $37, which could be reduced by mass production. The system consists of a single grease fitting mounted under the hood near the radiator cap and connected by nylon tubes to the lubrication points. Lubricating grease is pumped through the master fitting to steering and front-end assemblies in a single, one-minute operation.

Changes of Mechanical Properties of Lubricating Greases When Mixed

S. M. Meshchaninov and N. P. Zabelina Proizvodstvo Smazochnykh Materialov 1959, No. 5, 44-54.

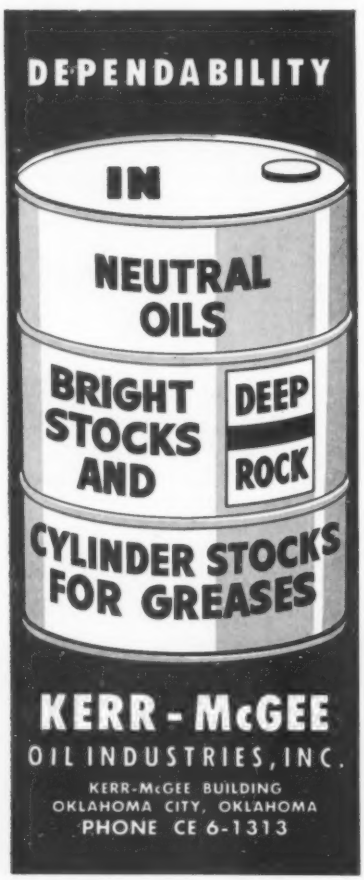
The authors stress the fact that even if lubricating greases of different types will provide normal lubrication of a bearing, a mixture of the two types may cause damage. This is because a second type may cause deterioration of the initial mechanical properties of the first type. However, it is pointed out that a used lubricating grease can be mixed with fresh grease of the same type without harm.

Greases to Prevent Fretting Corrosion

N. A. Scarlett, *Engineering* (London) v. 189, March 25, 1960, pp. 424-5.

Tests of 32 lubricating greases, using the Fafnir friction-oxidation rig, are reported. In addition, a description of what constitutes fretting corrosion and means for minimizing the damage due to fretting is given. The latter listing includes: "By the use of lubricants." Seven references are given.

The lubricating greases tested, with three exceptions, contained soaps as thickeners. One product consisted of a paste of petrolatum and 52 per cent molybdenum disulfide. Two products are listed as not



LUBRICATING GREASES • METALWORKING LUBRICANTS • SPECIAL PROCESS OILS
BEMOL
BEMOLybdenum
Fortified Lubricants
Never Underestimate the Importance of Protective Lubrication
mbi
ON GUARD SINCE 1888
MAGIE BROS. OIL CO.
Franklin Park, Illinois • Chicago Phone TU 9-4800

known both as to thickener and oil. The viscosities of the oils in the lubricants varied from 45 to 1,100 seconds Redwood 1 at 140°F. The consistency of the lubricating greases used in the tests varied but in the main were No. 2 NLGI Grades. Four products are listed as containing additives, one having a polar non-EP, two having one type of EP and the last another type of EP additive with no proportion listed. Also, eight lubricants contained molybdenum disulfide varying in percentage from ten to 65, two contained five per cent of graphite and two contained zinc oxide (proportion not given).

In the test the bearings were all steel, the load 600 pounds, and the oscillation was 6° at 1,420 cycles per minute. All samples were run for 50 hours but since this gave little differentiation between the most satisfactory products, seven lubricants were also tested for 1,000 hours.

The Literature and Patent Abstracts column is written for NLGI by C. J. Boner, director of laboratories for Battenfeld Grease and Oil of Kansas City, Missouri.

The two lubricating greases which exhibited the greatest protection against fretting corrosion contained additives. In one case a lithium base lubricant contained a polar non-EP additive. The oil in this case was 170 seconds and the penetration 265 to 295. The other satisfactory product was calcium base having an oil of 350 seconds and an EP additive. Here again the penetration was in the 265 to 295 range.

Some of the conclusions of the author are:

1. The types of soap and oil do not appear to be major factors.
2. E.P. properties are not a necessity in preventing fretting.
3. The evidence does not support indiscriminate use of molybdenum disulfide to reduce fretting.
4. Graphite did not aid in preventing fretting.
5. A reduction in soap content leads to improved anti-fretting properties.

Book

Chemical Technology of Petroleum, Third Edition, Gruse and Stevens, McGraw-Hill Book Co., 1960.

This 675-page book devotes three pages (544 to 547) to lubricating greases but no specific heading or space to gear lubricants. However, in the last paragraph of the grease section, when speaking of EP agents, the statement is made: "These latter are much employed in the semifluid greases known as gear oils, used for lubricating gear systems of power-transmitting devices."

FATTY ACIDS by A. GROSS provide

- Controlled fatty acid radical content
- Controlled purity content
- Ease of saponification
- Resistance to oxidation
- Shipment to shipment uniformity
- Light color

GROCO 8 DISTILLED RED OIL

Titre	8°-10°C
Titre	46.4°-50.0°F
Color 1" Lovibond Red	1 max.
Color 1" Lovibond Yellow	10 max.
Unsaponifiable	1.5% max.
Saponification Value	198-203
Acid Value	197-202
% F.F.A. as Oleic Acid	99 min.
Iodine Value (WIJS)	92 max.
Refractive Index 50°C (Average)	1.4495

a. gross & COMPANY

ALWAYS MEASURABLY BETTER THAN THE SPECIFICATIONS CALL FOR

COMPOSITION

Myristic Acid	5%
Palmitic Acid	6%
Stearic Acid	2%
Oleic Acid	77%
Linoleic Acid	9%
Linolenic Acid	1%

295 Madison Ave., N. Y. 17, N. Y.
Factory: Newark, New Jersey

Distributors in principal cities
Manufacturers since 1837

Write for new edition of the free brochure, "Fatty Acids in Modern Industry."

Industry News

Bel-Ray Introduces "No-Flame" Grease

Since its newest special lubricant is termed a sensational advance in grease compounding, the Bel-Ray Company, Farmingdale, N. J., introduces it in an unusual manner.

Called "No-Flame" grease because it won't burn under any conditions, the new specialty that is also non-melting and maintains its stability under all extremes of temperature and of pressure is being made known to prospective markets with a mailer that does a rather unique kind of sampling.

The mailer contains a cellophane blister with a glob of "No-Flame" grease in it and a packet of matches and this message right beside it: "Go ahead—try—No-Flame Grease won't burn."

The grease is white—and looks as pure as bakery shortening—against the black background for the blister pack. This attractive whiteness, an important feature, is permanent. "No-Flame" grease doesn't discolor under extremes of temperature or pressure; it is non-carbonizing and non-corrosive, and the whiteness is the visual sign for the high degree of stability.

Break Ground for New ADM Chemical Center

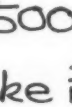
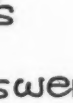
Construction by Archer-Daniels-Midland company of a multi-million dollar chemical center at Peoria underscores the company's growing diversification in the chemical field, said the president of ADM last month.

John H. Daniels, speaking at a civic luncheon preceding the groundbreaking for the new plant, pointed out that this emphasis on chemicals is a natural outgrowth of ADM's long experience in the research, processing and marketing of vegetable and marine oils.

Immediately after the luncheon, the ADM chairman and president broke ground for the new plant with two Peoria-made earthmoving machines, a Caterpillar and a LeTourneau Westinghouse.

Self-Emulsifiable Sperm Oil

An entirely new product, self-emulsifiable sperm oil, has been developed by Werner G. Smith, Inc. of Cleveland, Ohio. Known as W-G-S Sperm Oil "42," the new

If it rolls on an axle or turns in a bearing or rides on a shaft if it slides in a groove or moves on a pivot if it bores or cuts  or transmits pressure  one of Sinclair's 500 specialized lubricants is designed to make it work better. For answers to your lubrication problems, write today to

SINCLAIR REFINING COMPANY Sinclair

Technical Service Division, 600 Fifth Ave, N.Y. 20 N.Y.

product provides all the desirable lubricating properties of sperm oil, plus easy emulsification by simply agitating with hot or cold water. Permanent emulsions are formed with as little as 5 to 10 per cent W-G-S "42" and 90 to 95 per cent water.

The new product is *not* water soluble and very low percentages of Sperm Oil "42" (such as 1 per cent) will *not* form emulsions. Because it is in an emulsion and not a solution, the sperm oil will coat metal and form an oil film which will not wash off with water. This is important for many lubrication applications. Like sperm oil, the emulsifiable sperm oil possesses high film strength and has an affinity for metal and other surfaces. It will plate out in a continuous mono-molecular film and a small amount will cover a large area, adding to economy when used as an additive.

Sperm Oil '42" contains a chemically-bound emulsifier and has low-viscosity and anti-rust properties. It is stable in acid or alkaline solutions and soluble in petroleum solvents. It is non-toxic, has less odor than sperm oil, contains no sulfuric acid, sulfates, sulfonates, nor added non-ionic emulsifiers. An amber-colored liquid at room temperature, W-G-S Sperm Oil "42" forms a creamy emulsion with water.

To provide extreme pressure properties, it can be reacted with chlorine or phosphorus. To make it water soluble, it can be sulfated or reacted with ethylene oxide or strong alkalis.

Suggested uses include cutting oils, steel rolling oils, textile and leather oils, petroleum additives and many other chemical reactions. Available in steel drums, tank cars, tank wagons. Samples, prices and technical service on request.

Increases Tool Life

From 100 to 300 per cent increased tool life has been reported from Europe through the use of Molykote PVE, a bonded lubricant coating for ferrous surfaces just introduced to this country by the Alpha-Molykote corporation. Containing no resin binder, the new compound should not be confused with conventional solid-film bonded lubricants as it requires neither chemical nor mechanical surface pre-treatment, such as phosphating and sandblasting, nor oven curing. Molykote PVE is simply applied with an ordinary paint spray gun, and the material dries within five hours to a thin, tough film in air at room temperatures.

Among the tools which have been successfully treated in Europe are twist drills, reamers, broaches and gear cutters and bending tools. In one production test the coating of 500 miscellaneous cutting tools with Molykote PVE gave the following results: 100 per cent increase in gear shaper tool life; 150 per cent increase in broach life; and 300 per cent increase in the life of tools for cutting aluminum. In one instance of use on bending tools, the number of parts produced per tool was increased from 3,000 to 40,000.

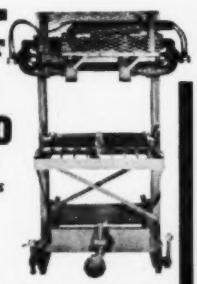
McGEAN
30% LEAD NAPHTHENATE ADDITIVE

- Consistently uniform in metallic content and viscosity
- Fully clarified by filtration
- Non-Oxidizing - - - contains no unsaturated soaps
- Free from low flash constituents

McGEAN CHEMICALS

THE McGEAN CHEMICAL COMPANY
1040 MIDLAND BLDG.
CLEVELAND 15, OHIO

BARRETT
GF-35
GF-120
Semi-Automatic Filling Machines



Model GF-35/Pails
Model GF-120/Drums
For grease and other viscous products. Air operated. Fills 15 pails per minute. (No Pail—No Fill)
- Sensitive adjustment assures accuracy
- Volumetric measure assures consistency

BARRETT
Manufacturing Co.
P. O. Box 8096, Houston 4, Texas

SIGN OF
CORRECT LUBRICATION
Mobil

Makers and Marketers of
Mobil Automotive Products
Mobil Industrial Oils and Greases

150 E. 42nd STREET
NEW YORK 17, N. Y.

People in the Industry

Wins SAE's Springer And Henry Ford Awards

Theodore W. Selby, senior research chemist for General Motors Research Laboratories fuels & lubricants department, received both the Russell S. Springer and Henry Ford Memorial awards from the Society of Automotive Engineers.

Presented by the national SAE, the Springer award goes to the youngest author of a technical paper of permanent interest to be accepted and published in SAE *Transactions*. The Henry Ford award, presented by the Detroit SAE section, goes to the junior SAE member who writes the best technical paper on ground vehicles in the year.

This is the first time the two awards, for which only SAE members under 33 years of age can compete, were presented to the same man. Also unique is the fact that both awards were made for the same technical paper authored by Mr. Selby, "Automatic Transmission Fluid Viscosity at Low Temperatures and Its Effect on Transmission Performance."

A native of Nebraska City, Neb., Mr. Selby was graduated from Chicago's St. Rita high school. He received his bachelor of science degree in 1950 from the University of Detroit, and was awarded a master's degree in chemistry from Wayne State university. He is now working on his doctor's degree in chemistry at Wayne State.

Before joining GM Research Laboratories in 1953 as a member of the chemistry department, Mr. Selby was a research associate at Marygrove. In 1955 he transferred to fuels & lubricants department where he specializes in physical characterization of lubricating oils and transmission fluids.

He is the fourth member of GM Research fuels & lubricants department to receive the Springer award since 1954.

Atlantic Names H. B. Elliott

The Atlantic Refining company has announced the appointment of H. B. Elliott as manager of the industrial products division in the firm's special sales department. He succeeds George Landis, who is retiring after more than 48 years of service with the company.

A graduate of Lehigh university, Elliott joined Atlantic in 1938 as an industrial lubricating salesman. He has served in the industrial products division since 1956 and in 1959 was named assistant manager. (For other news about Elliott, see page 362.)

Climax Appoints W. M. Stilwell

William M. Stilwell has been appointed manager of lubricant sales and development for Climax Molybdenum Co. He succeeds Kenneth B. Wood, Jr., who was recently promoted to manager of chemical sales.

Mr. Stilwell joined the company in 1955 as assistant manager of lubricant sales and development. He served as manager of agricultural sales and development, prior to his new appointment.

HARSHAW LEAD BASE

Harshaw Lead Base, as an additive to petroleum lubricants, improves extreme pressure characteristics and imparts the following desirable properties:

- Increased film strength
- Increased lubricity
- Improved wetting of metal surfaces
- A strong bond between lubricant and metal surfaces
- Resistance to welding of metals at high temperatures
- Moisture resistance and inhibits corrosion

Harshaw Lead Bases are offered in three concentrations to suit your particular needs:

Liquid	Liquid	Solid
30% Pb	33% Pb	36% Pb

Other metallic soaps made to your specifications. Our Technical Staffs are available to help you adapt these products to your specific needs.

THE HARSHAW CHEMICAL Co.
1945 E. 97th Street • Cleveland 6, Ohio
Branches In Principal Cities

The C. W. Nofsinger Company
CONSULTING ENGINEERS
Grease Plants
Petroleum Refineries
Petrochemicals
"In Engineering It's the People That Count"
307 East 63rd Street
Kansas City 13, Missouri

LUBRICATING GREASE TECHNOLOGIST

Long-established manufacturer of specialty greases in New York area offers excellent opportunity to competent man.

Must be experienced in conducting usual laboratory and research work; also have know-how and experience in production of sodium, calcium, mixed base and lithium lubricants—both with and without additives such as EP, rust preventatives, etc.

Must be qualified, after suitable "breaking in" period, to act as assistant to Plant Superintendent in supervising production and other operations.

Applications invited from men holding similar position or from chemist with required experience and capabilities. Held in strictest confidence. Position is permanent, good compensation, with advancement.

Give full particulars of past training and experience, including salary range, age and marital status. Send photo.

BOX 1576 GRAND CENTRAL STATION
NEW YORK 17, NEW YORK

THE CASE FOR LITHIUM: **IONIC SIZE**

Pauling's formulation of univalent crystal radii indicates that the lithium ion is indeed the smallest alkali metal ion.

ATOMIC AND IONIC RADII OF ALKALI METALS (PAULING)

	Li	Na	K	Rb	Cs
M (Angstroms)	1.225	1.572	2.025	2.16	2.35
M+ (Angstroms)	0.60	0.95	1.330	1.48	1.69

Lithium's small ionic radius permits shorter internuclear distances between cation and anion. Thus, the lattice or crystal energies of lithium salts should be higher than those of other alkali metal salts. An analysis based on the Born-Haber cycle readily shows this to be true.

The heats of formation of large anion lithium compounds are usually lower than other alkali metal compounds due to lithium metal's high ionization potential and heat of sublimation. But this is not true for small anion lithium compounds. LiF, Li_2O, LiH, Li_2C_2, Li_2S, and Li_3N are all more stable than their other alkali metal congeners. And the freedom with which lithium combines with small anions may well be responsible for its excellent performance in metal scavenging and degassing.

IONIC POTENTIAL The concept of ionic potential (ionic charge/ionic radius) successfully relates the charge densities and deforming powers of the alkali metal ions. Lithium, of course, has the highest ionic potential of the alkali metals, and therefore, the highest free energy of hydration. And a modified Born-Haber cycle shows that lithium in aqueous systems matches cesium as the strongest reducing agent of the alkali metals.

SOLVATION ENERGY High ionic potential is also responsible for the unusual solubility behaviors of ionic lithium compounds. Lithium's high solvation energy favors breakdown of the ionic crystal lattice by solvent-ion interaction. Thus, the utility of LiH and $LiAlH_4$ as reducing agents. Unlike NaH and $NaAlH_4$, they are relatively soluble in diethyl ether, a desirable medium.

One indication of the extensive solvent-ion interaction suggested is the high hydration energy of the lithium ion . . . leading to an increase in lithium ion size in solution. The size increase is due to an adhering sheath of solvent molecules or dipoles. Thus, the lithium ion, smallest of the alkali metal ions in the solid state, is the largest in solution in water.

IONIZATION POTENTIAL AND RELATED PROPERTIES OF THE ALKALI METALS

	Li	Na	K	Rb	Cs
Ionization Potential (electron volts)	5.390	5.138	4.339	4.176	3.893
Oxidation Potential (E_o at 25°C, volts)	3.02	2.71	2.92	2.99	3.02
Heat of sublimation (kcal, 25°C)	36.44	25.95	21.52	20.50	18.83
Heat of Hydration of Gaseous Ion (kcal/mole)	123	97	77	70	63

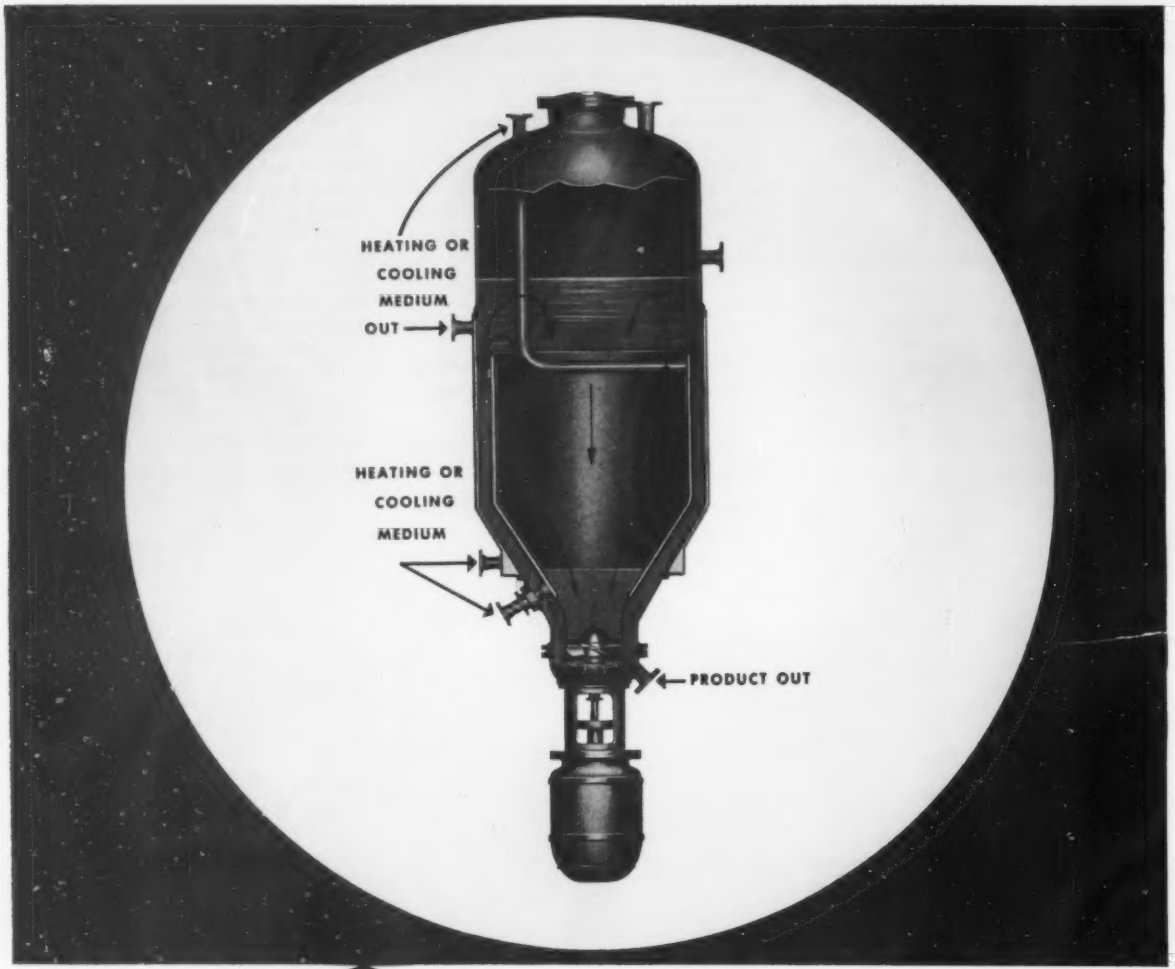
The lithium ion—water dipole aggregates are probably responsible for the severely negative deviations from ideal solution behavior exhibited by lithium salts in solution. Lithium salts yield solutions with abnormally low colligative properties . . . very low aqueous vapor pressures, very low freezing points, etc. . . . as well as the highest stoichiometric activity coefficients of all the alkali metals. For equivalent molar concentrations of alkali metal salts, lithium salts have the highest effective thermodynamic concentrations, the basis for the superior performance of lithium bromide solutions in absorption refrigeration, and of lithium chloride solutions in humidity control equipment.

BOND CHEMISTRY With the highest electronegativity of the alkali metals, lithium has the greatest tendency to form covalent or mixed covalent bond types. Thus, lithium alkyls tend to be much more covalent than corresponding sodium alkyls, and as a result are far more soluble in non-polar solvents. But there is still sufficient polar or ionic character to the lithium-carbanion bond to exert an orienting force on such reactions as the stereospecific polymerization of isoprene.

MORE TO COME The tale of lithium is neither easily nor quickly told. The material presented here constitutes the briefest of introductions. But if it has whet your appetite, we can happily provide you with a great deal more of the same . . . long on facts and ideas, short on flim-flam, and complete with derivations and references. Just write for a copy of "Lithium vs. The Other Alkali Metals". Foote Mineral Company, 402 18 West Chelten Building, Philadelphia 44, Pennsylvania.

FOOTE
MINERAL COMPANY

Lithium has more than once been called the unexpected metal. A member of Group IA, it shares many generic properties with the other alkali metals. But its primary usefulness has always derived in some way from its many and varied differences. *A number of the more interesting of these differences are discussed here, all of them related to the fact that, under varying circumstances, lithium has at once both the smallest and the largest of the alkali metal ions*



THE STRATCO CONTACTOR

Reg. U. S. Pat. Off.

Simplifies and Lowers Cost of Grease Manufacture

Completes saponification of all soaps with very short time cycles, reduces amount of soap required, simplifies laboratory control and reduces man hours of operation . . . consequently, lowers costs.

Adaptable to existing plants and a vital part of all complete grease plant installations. Also employed advantageously for sulfurization of oils.

Available in capacities from 2 gallon laboratory units to 2800 gallon commercial sizes.

STRATFORD ENGINEERING CORPORATION

• **PETROLEUM REFINING ENGINEERS**

612 West 47th St. Kansas City 12, Mo.

REPRESENTATIVES

D. D. Foster Co., Pittsburgh, Pa.
D. D. Foster Co., S. Charleston, W. Va.
Lester Oberholtz, Los Angeles
Rawson-Houlihan Co., Inc., Houston
Rawson-Houlihan Co., Inc., Beaumont, Texas
The Rawson Co., Inc., Baton Rouge
F. J. McConnell Co., New York

C760